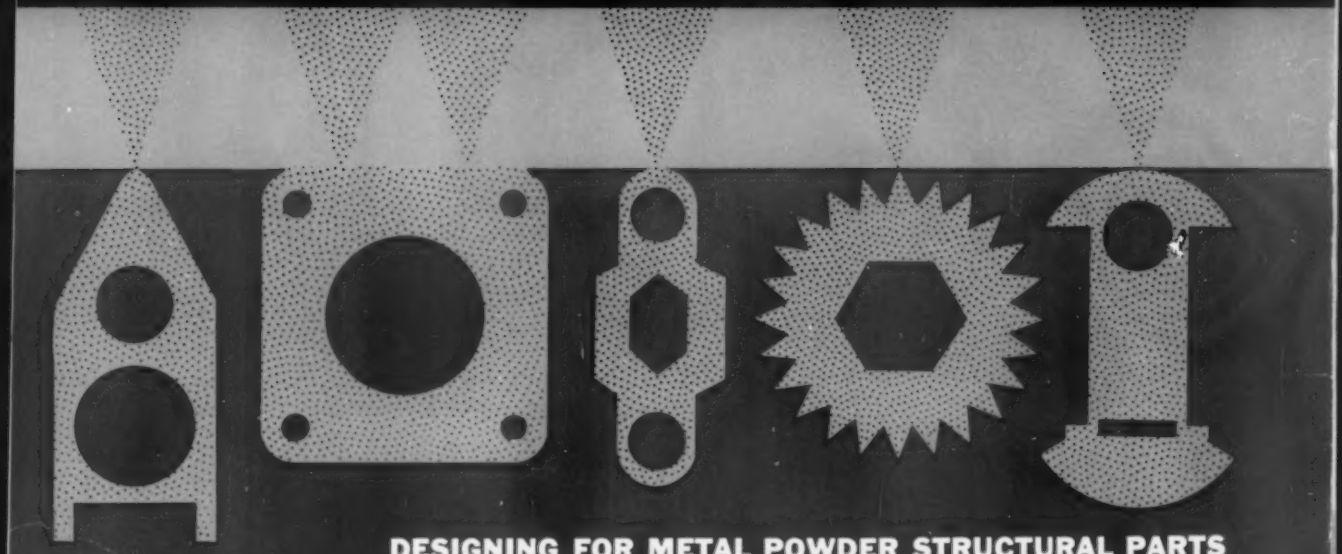
Materials in Design Engineering

FORMERLY MATERIALS & METHODS

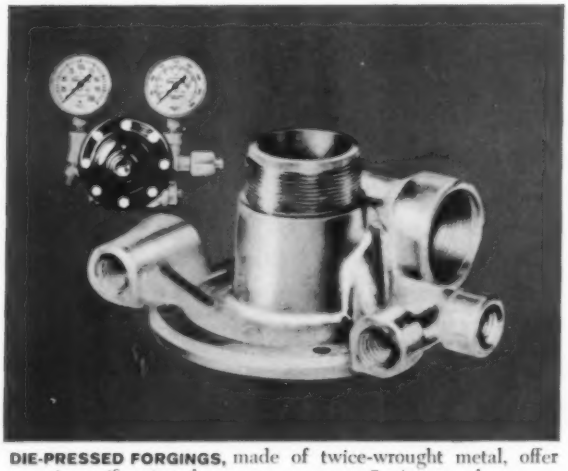
SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES



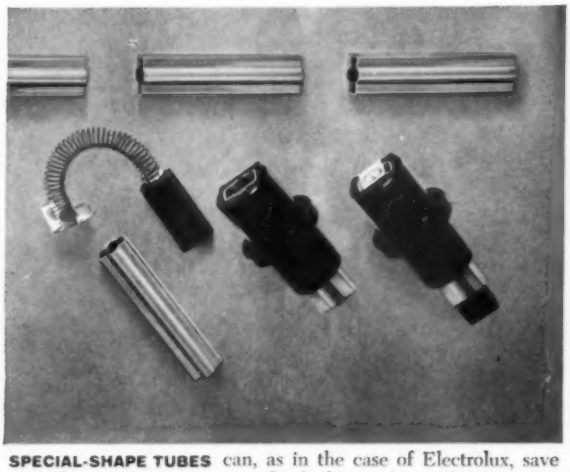
DESIGNING FOR METAL POWDER STRUCTURAL PARTS

...L. 1959 MANUAL NO. 158 ALSO: CERMET COATINGS WHAT'S NEW IN PLASTICS COMPLETE CONTENTS - PAGE 3

TAKE A FRESH LOOK at the way you are fabricating metal parts. Cost-cutting possibilities are almost unlimited with these Anaconda pre-formed mill products and press products.

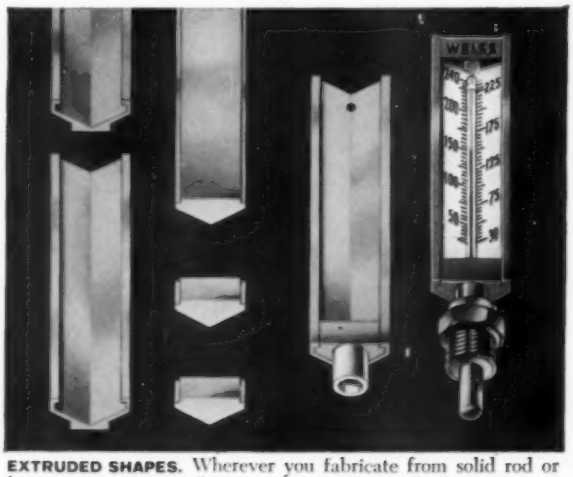


DIE-PRESSED FORGINGS, made of twice-wrought metal, offer superior uniformity, denseness, accuracy. *Savings*: replace more costly built-up assemblies—often are less in first cost than sand castings—require minimum surface machining to size—simplify secondary operations—lower tool cost—lower finishing cost.



SPECIAL-SHAPE TUBES can, as in the case of Electrolux, save several steps in arriving at a finished part. Brass electric-motor brush holder (above) is cut economically from long lengths of tube pre-shaped to accommodate both brush and spring. Uniform accuracy of all dimensions helps provide good brush stability.

MULTIPLE-PLUNGER AND PROGRESSIVE-TOOL-PRESS PRODUCTS are cutting costs throughout industry—often over 50%. Main reasons: The American Brass Company's complete design engineering service, long experience, specialized production equipment, a big selection of stock tools. Metals: copper, copper alloys, nickel, iron, steel, stainless steel, or aluminum.



EXTRUDED SHAPES. Wherever you fabricate from solid rod or bar—or castings—consider savings in machining, tooling and scrap by use of extruded shapes. Albert A. Weiss & Sons substituted two extruded shapes, above, for a sand casting—cut cost of thermometer case 41%, got an additional 30% saving in assembly because of consistently uniform dimensions.

HERE are four immediate approaches to cutting costs. Re-evaluate your designs and fabrication methods with these short cuts to finished products in mind. Wherever you spot a possible saving, send a sample, drawing, or description—with the quantity you need, the metal or properties you require—and ask for a quotation. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ontario. 2453

DIE-PRESSED FORGINGS • SPECIAL-SHAPED TUBES
EXTRUSIONS • FABRICATED METAL GOODS

products of

ANACONDA®

Made by The American Brass Company

For more information, turn to Reader Service card, circle No. 489

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Materials
in Design Engineering, *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

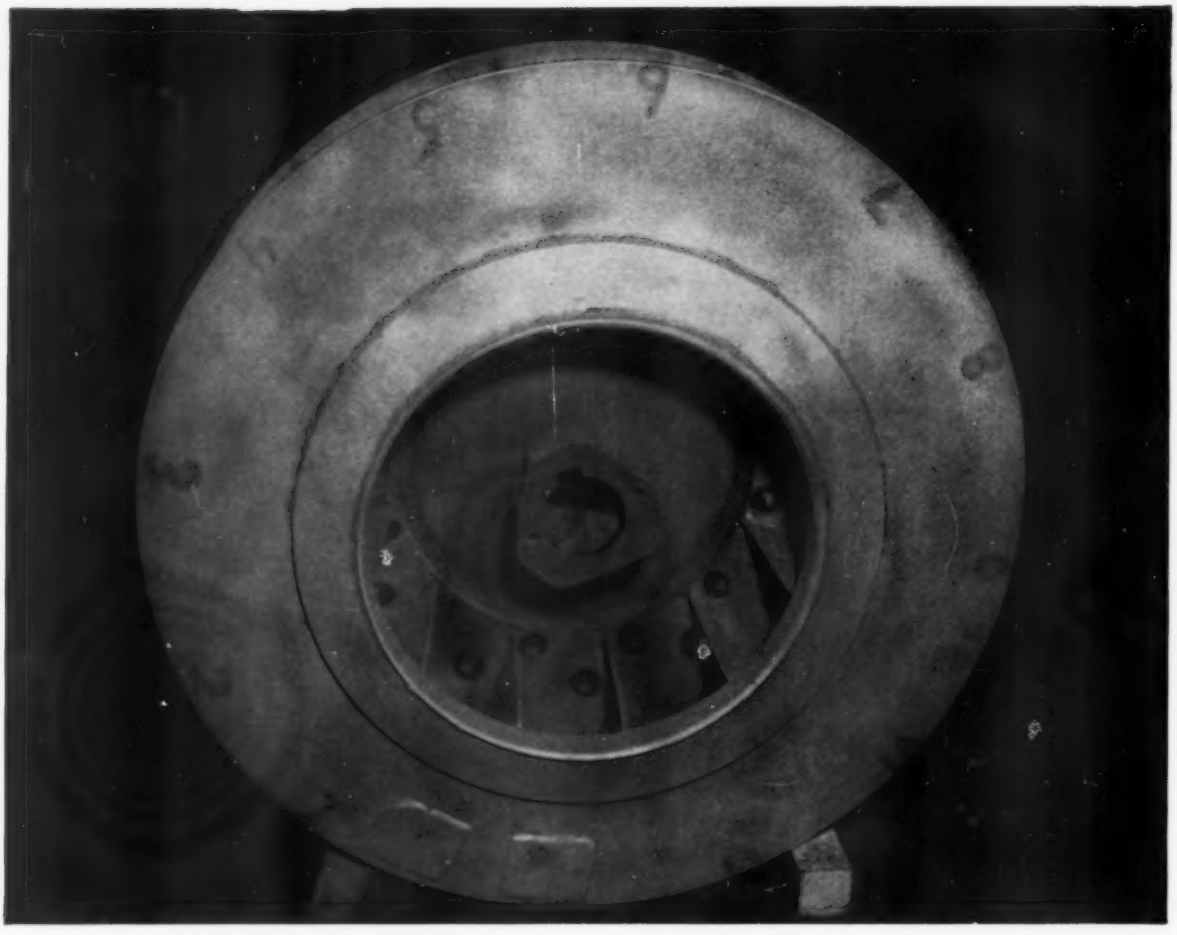
APRIL 1959
VOL. 49, NO. 4

FEATURES

MANUAL NO. 158

DEPARTMENTS

COVER BY HARRY & MARION ZELENKO



New blower...its cast Inconel hub takes stresses of 3500 RPM spin in hot corrosives

It spins at 3500 RPM in a fiery, corrosive-gas-laden environment.

That's why this new blower, made by Buffalo Forge Company for a major chemical producer, is made of Inconel* nickel-chromium alloy parts.

Inconel alloy provides a high combination of strength and corrosion resistance at high temperatures.

Inco foundry casts critical hub

Buffalo Forge took no chances with the most critical part in the blower. To be *sure* that exacting specifications were met, they had the makers of Inconel alloy make the hub casting. As long-term customers of Inco's Bayonne, N. J. foundry, they knew they could depend on Inco to produce a sound, uniformly strong casting; one that would bring out the best that was in the alloy.

Take a tip from Buffalo forge...

When you design for extreme conditions, consider the properties of Inconel alloy. And, if the part is to be cast, call on Inco to cast it.

A 9-page Inco technical bulletin, "Engineering Properties of Cast Inconel Alloys", gives the data you need...compositions, physical properties, machining procedures, and much more. We'll be more than glad to send you a copy. *Registered trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

INCO TRADE MARK

INCO-CAST PRODUCTS

For more information, turn to Reader Service card, circle No. 415

What's new IN MATERIALS

...AT A GLANCE

A new high temperature, highly fluorinated synthetic rubber has been developed for use in red fuming nitric acid, 96% hydrogen peroxide, silicate esters, aromatic fuels and hydraulic fluids. The developer says the elastomer, which contains more than 60% fluorine by weight, is useful at temperatures between 400 and 600 F. It will probably be most competitive with Du Pont's Viton. Introductory price is $15 per lb. (More details next month.)

Source: Minnesota Mining & Mfg. Co., 900 Bush St., St. Paul 6, Minn.

Pure tungsten can now be forged, spun, deep drawn and extruded by new hot working techniques. Forming is done very quickly, since parts are made at such extremely high temperatures that tools would melt if they came in prolonged contact with the hot tungsten. (Watch for more details in a forthcoming issue.)

Source: Fansteel Metallurgical Corp., North Chicago, Ill.

High quality, heavy nickel deposits are being applied to parts by a new coating technique that is said to be much faster than electrodeposition or electroless nickel plating. A major benefit of the method is that the deposits exactly reproduce patterns on which they are applied without the use of machining. Nickel is deposited by passing carbon dioxide over nickel scrap at 450 F to produce a condensate of nickel carbonyl. The condensate is kept under pressure and released into a heated mold where it is thermally decomposed to lay down a nickel deposit.

Source: Budd Co., 2450 Hunting Park Ave., Philadelphia 32.

A glass that fuses directly to stainless steel has been developed. The new material, a pressed and sintered glass, has a coefficient of thermal expansion of 5.4×10^{-6} per °F, a working point of 1700 F, a softening point of 1260 F, and an annealing point of 910 F. The glass is expected to find use in electronic parts.

Source: Corning Glass Works, Corning, N. Y.

Two heat resistant stainless steels for gas turbine engines and missile and aircraft parts have been developed. Both are precipitation hardening alloys and can be readily forged and welded. One alloy keeps its strength at temperatures up to 1500 F. The other combines excellent tensile strength with good stress-rupture properties, and can be fabricated into large shapes by the consumable-electrode vacuum remelting technique. (More details next month.)

Source: Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22.

Corrosion resistant, non-brittle welds in titanium, zirconium, vanadium, tungsten, tantalum molybdenum and other metals can be obtained by using vacuum welding equipment recently made available. Up to now vacuum welding was an experimental process. Welds are produced by the concentrated energy of a focused beam of high

velocity electrons. The vacuum atmosphere is pure to less than 1 ppm; the best commercially available inert gases are pure only to 15 to 20 ppm.
Source: High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.

Lubricants for 700-1000 F operation are promised with the development of meta-polyphenyl ethers. A typical meta-ether is said to have a liquid range of 35-1000 F, a calculated life of over 50 hr at 900 F, a 210 F viscosity of 12.72 cs, and an ASTM (viscosity-temperature) slope of 0.85 from 77 to 700 F. As a class, meta-ether fluids have good lubricity and hydrolytic, oxidative and radiation stability. They are said to be as stable at about 840 F as silicones at 740 F, hydrocarbons at 660 F, and the esters at 540 F.
Source: Monsanto Chemical Co., St. Louis, Mo.

Hot extrusion of ductile iron has been accomplished by Watertown Arsenal. Tests show rods and tubes extruded by the process have better strength and ductility than cast ductile iron parts. The billets are cast to size and extruded at 1800 F using glass lubrication.
Source: Watertown Arsenal, Watertown, Mass.

Titanium carbide tools with up to seven times better tool life than the usual grades of tungsten carbide have been developed. Tests show a titanium carbide tool bit cuts through more than 200 lb of metal before wearing out, compared to a tungsten carbide tool bit which wears out after cutting through about 85 lb of metal. A combination of nickel and molybdenum is used as the bonding agent for the titanium carbide.
Source: Ford Motor Co., Engineering & Research Staff, Dearborn, Mich.

Colored magnesium parts can be produced by applying dyes over a uniform anodic coating. Colors can be applied to all magnesium alloys but are best suited for wrought alloys because of their more uniform surface. The colored coatings are durable and have good resistance to fading. They are expected to be used for decorative purposes on commercial products and as identification on military products.
Source: Western Sealant Metal Finishing Co., 1721 N. Front St., Philadelphia.

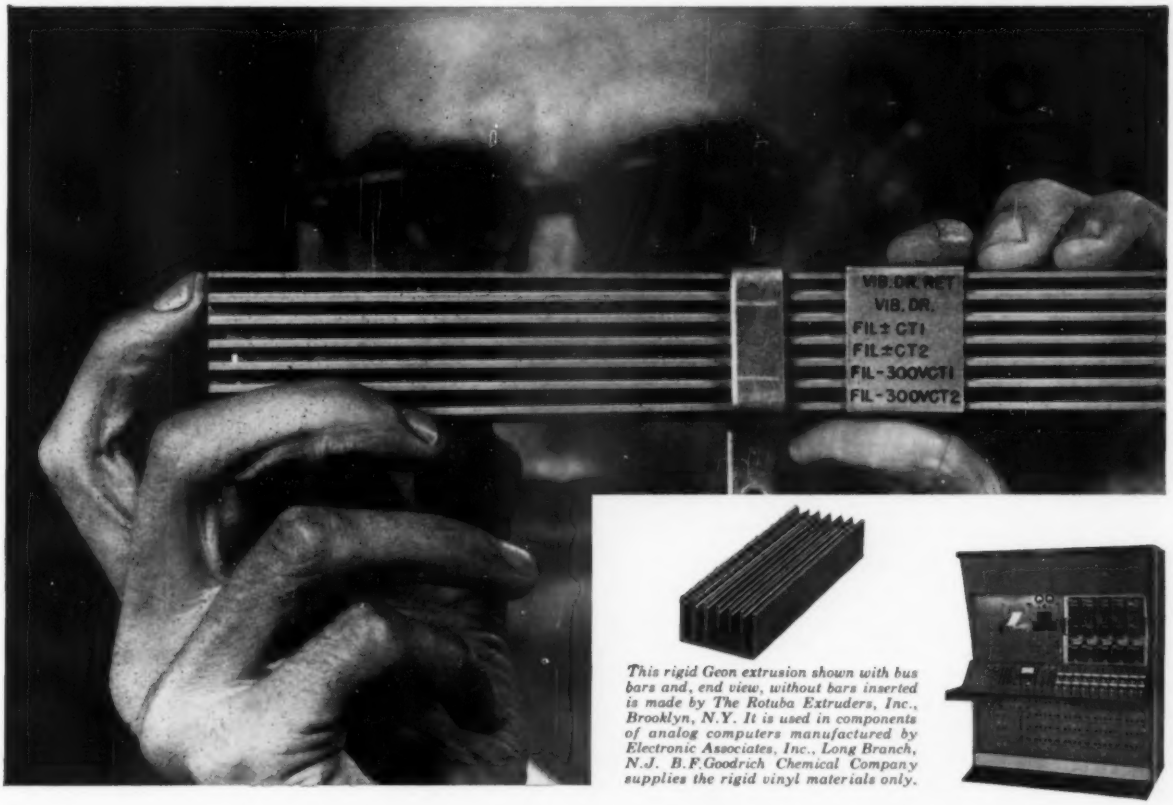
High purity molybdenum metal powder is being produced by a new technique in which molybdenum oxide is reduced to metal in a single operation. The developer says the single-stage reduction process is capable of turning out five to eight times more molybdenum powder than can be obtained by current two-stage methods. The new process can also be used to make high purity tungsten powder.
Source: Metals and Residues, Inc., 65 Brown Ave., P.O. Box 92, Springfield, N. J.

A new vinyl-metal adhesive keeps its bond after exposure to: 1) boiling water for 30 min; 2) dry heat for 7 days at 200 F; 3) tap water for 240 hr at room temperature; and 4) 100% RH for 1000 hr at 160 F. Vinyl-metal laminates bonded with the adhesive can be stretched 35% without damage.
Source: B. F. Goodrich Industrial Products Co., Div. of B. F. Goodrich Co., Akron, Ohio.

Turn to page 129 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*



This rigid Geon extrusion shown with bus bars and, end view, without bars inserted is made by The Rotuba Extruders, Inc., Brooklyn, N.Y. It is used in components of analog computers manufactured by Electronic Associates, Inc., Long Branch, N.J. B.F.Goodrich Chemical Company supplies the rigid vinyl materials only.

Extrusion of rigid Geon

. . . cuts bus bar insulation costs, saves assembly time

This extrusion of Geon rigid vinyl material saves cost, time and space for electrical assemblies. It is used to retain and insulate six strip-type bus bars of varying voltages up to 600 volts DC. They can be placed closer together because of rigid Geon's high dielectric strength and high insulation value.

Rigid Geon brings material costs down, too, for this application. It also shortens assembly time and saves weight and space.

In addition, the use of extrusions made from Geon rigid vinyl material provides good chemical and abrasion resistance. If desired, they can be colored for coding purposes. It's another example of the way Geon rigid vinyl can be the key to a new or improved product or application. For information, write Dept. AR-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR American rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

For more information, turn to Reader Service card, circle No. 367

MATERIALS AT WORK

...AT A GLANCE

Vinyl-coated fabric dampens jet roar

Thanks to a new vinyl-coated fabric, jet airliner passengers will not be disturbed by the roar of the engines. The new acoustical panel, which is designed to absorb low frequency sounds, consists of either cotton or glass fabric treated with a vinyl plastisol containing powdered lead. To make the panels, lead powder is mixed into the vinyl plastisol formulation and spread-coated onto the fabric. The result is a flexible material with sufficient mass to absorb low frequency sounds.

Source: B. F. Goodrich Chemical Co.; material developed by Mobile Plastics Div., Cordo Chemical Co.

First all-aluminum aircraft hangar

An all-aluminum aircraft hangar, believed to be the first in this country, has recently been erected at Byrd Field, Richmond, Va. Over 69 tons of extruded aluminum shapes are used for the structural framework, and an additional 30 tons are used for the roofing, siding, sliding doors and other parts. Overall dimensions of the structure are 165 x 108 ft. Reasons given for the selection of aluminum: light weight, ease of fabrication and corrosion resistance.

Source: Reynolds Metals Co.; hangar constructed by Laburnum Construction Co.

Filled nylon door slide replaces metal

Switching from metal to molded molybdenum disulfide-filled nylon has resulted in a 10-20% saving in materials costs in the design of a slide for an oven door lockstop. Specifications for the slide called for heat and abrasion resistance, rigidity, strength, dimensional stability and tolerances to be held to +0.003 in. and −0.000. A filled nylon molding was selected because it satisfied these requirements (at relatively low cost) and was found to resist distortion even at temperatures approaching 400 F.

Source: Polymer Corp. of Pa.; used by Appliance Div., Westinghouse Electric Corp.

Stainless heat exchanger for heart surgery

A unique heat exchanger, composed of thin-wall, especially smooth i.d. stainless steel tubing, is being used to lower blood temperature in delicate open heart surgery. The unit is mounted between a heart-lung machine and the patient. Blood is cooled (and then warmed after the operation) by a parallel flow of water in the surrounding jacket. Type 304 stainless was selected for the exchanger's 24 tubes because it is completely resistant to chemicals in the blood, can be given an extremely smooth inside surface, and can be fabricated to extremely close tolerances: each of the 15.1-in. long tubes has a 0.210-in. o.d., a 0.020-in. wall, and an o.d. tolerance of +0.000, —0.001 in.

Source: Superior Tube Co.; unit developed by Radiator Div., General Motors Corp. in cooperation with Duke University Medical Center.

Magnetic glass device thinks fast

A magnetic device no larger than a pin may play an important role in the design of future electronic computers. The device, a glass rod covered with a magnetic coating, is said to serve as both a switching and information storage element. Top switching speed of the device is as yet unknown. However, research models have exhibited speeds as fast as 4 millimicroseconds, or about 10-20 times faster than

(continued on p 9)

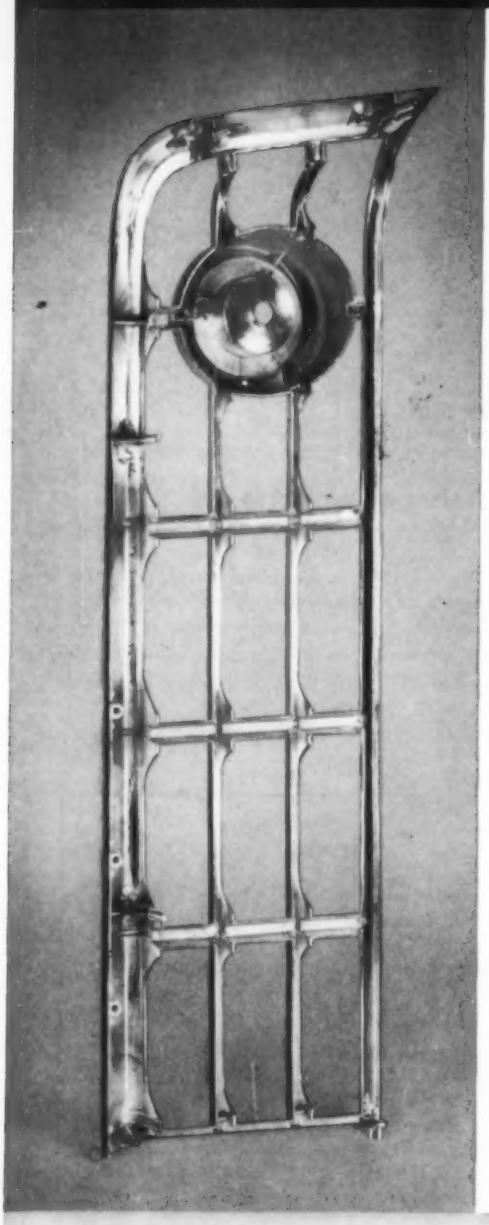
Briefs

Cordless television receivers which use transistors instead of vacuum tubes are currently under development. Requiring no electrical connection, the sets are powered by two rechargeable nickel-cadmium batteries and will operate for 6 hr before recharging is necessary.

A strip of gold 40 times thinner than a human hair (0.000080 in. thick) is said to be responsible for the hi-fi response of today's stero and monaural recording heads. The ultra-thin gold alloy (containing nickel, copper, and zinc) is used as a nonmagnetic gap in magnetic recording heads to transform energy from the amplifier into magnetic impulses.

Cardboard tubing is being used to protect instrumentation housed in iron tubing from heat in a new thermocouple used for immersion in steel baths. The cardboard tubing merely chars at temperatures up to 3000 F during brief immersion (5 sec).

IT'S LIGHTER THAN YOU THINK!



...AND MAKES A STRONGER GRILLE WHEN DIE CAST with ZAMAK

Each half of this substantial 1959 RAMBLER grille is made of a single light-weight zinc die casting—for strength and rigidity—with long-lasting chromium plating.

Complete with integrally cast lamp housings and mounting studs for rapid assembly, the grille on this popular American Motors automobile is designed for appearance, durability and economy.

As in many other applications, rugged but extremely thin wall sections—possible only with ZINC die castings—minimize weight and are stronger **in proportion to thickness** than heavier sections.

Parts designed for ZAMAK alloy die casting will meet competition of either stampings or aluminum castings—and at lower cost.

HORSE HEAD® SPECIAL ZINC AND HORSE HEAD ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

160 Front Street • New York 38, N. Y.

HORSE HEAD PRODUCTS®

For more information, turn to Reader Service card, circle No. 519

any presently available. The rod is about 0.015 in. in dia and is given a magnetic coating by a special electrochemical process.

Source: National Cash Register Co.

Cast retainer replaces forged die block

A saving of over $1200 resulted from the switch to a cast-to-shape retainer in place of a forged die block used to hold automobile horn dies. The cast-to-shape retainer, made of an oil or air hardening steel designated FC CMS, weighs 600 lb less than the forged die block it replaced. This saved $250. The big saving, however, resulted from the elimination of 150 hr of costly machining time. The only machining operation required with the cast part is the removal of about ¼-⅜ in. on all surfaces.

Source: Allegheny Ludlum Steel Corp.; casting made by Riehle Machine Co.; used by Congress Die Casting Div., Tann Corp.

Hard rubber-plated cylinders last longer

Excellent chemical and abrasion resistance, good tensile strength and high temperature resistance are the reasons given for the selection of hard rubber for plating cylinders used to handle hot corrosives. The cylinders, which are part of a 26-station automatic barrel plating system, are subjected to hot corrosive attack and mechanical wear from tumbling metal parts. Average load is 100 lb. The hard rubber material was found to give "at least double the life of any material used before in this application."

Source: American Hard Rubber Co., Div. of Amerace Corp.; used by Howard Plating Industries, Inc.

Extruded sprocket replaces machined part

Changing from machined round bar stock to hot extruded, cold drawn bar stock has resulted in a 50% cut in production cost of an SAE 8620 steel sprocket used to drive the chain in a power saw. The cost reduction resulted from the elimination of machining operations. Previously, the sprocket teeth were milled from 1¾-in. dia, ⅝-in. thick blanks cut from round bar stock. Now, the part is extruded and drawn with the finished tooth form and only deburring is necessary.

Source: Jones & Laughlin Steel Corp.; sprockets made by Lombard Governor Corp.

Glass-epoxy insulation prevents cold feet

Approximately one mile of glass cloth-reinforced epoxy laminates are bonded to the floor of each DC-8 jet transport. Reason: to prevent passengers from getting cold feet. The laminates not only insulate at high altitudes, but act as supports for the aluminum floor. Shaped in the form of a "U," each laminate section is 1 in. wide and 1 in. deep, with ¾-in. flanges at the base.

Source: Shell Chemical Corp.; DC-8 produced by Douglas Aircraft Co.

(more Materials at Work on next page)

Edited by
Walter Lubars

MATERIALS
AT WORK

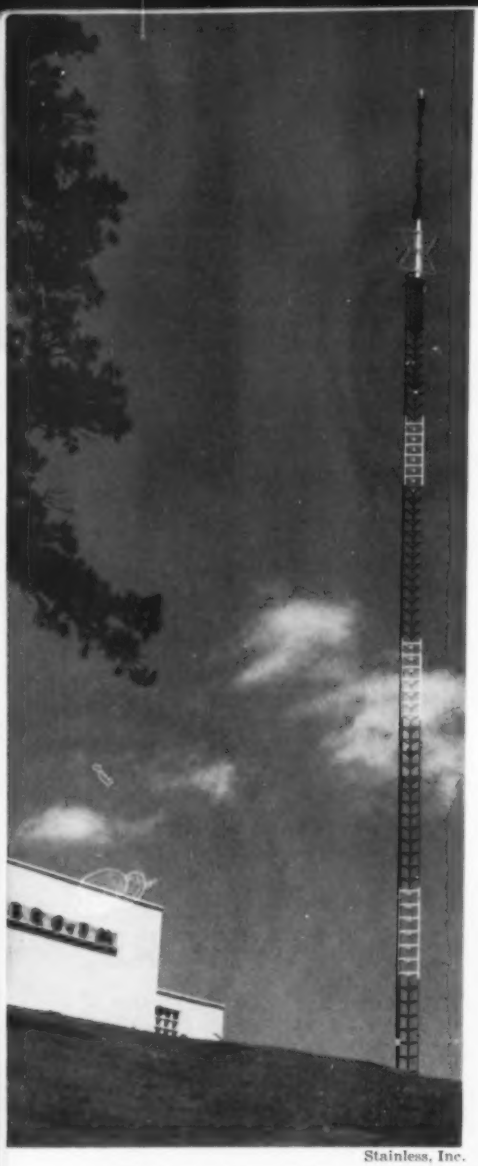
Welded steel tubing...

where it is used — and why

Shown in the accompanying photos (supplied by the Formed Steel Tube Institute) are some of the applications for which welded steel tubing is suited.

According to the Institute, the major reasons for welded steel tubing's increasing popularity are: 1) uniformity of wall thickness, strength and surface qualities; 2) concentricity; 3) workability; 4) weldability; 5) dimensional accuracy; and 6) low cost, both in initial investment and in the elimination of secondary operations.

Welded steel tubing can be bent, flared, tapered, spun, flattened, beaded and upset. It can be joined by all welding methods and mechanical means. As-welded tube is available in a range of standard sizes from 1/4 to 5 1/2 in. and in wall thicknesses from 0.025 to 0.120 in. (cold rolled) or 0.065 to 0.269 in. (hot rolled). Tolerances are ±0.002 in. on the small diameter tubing.



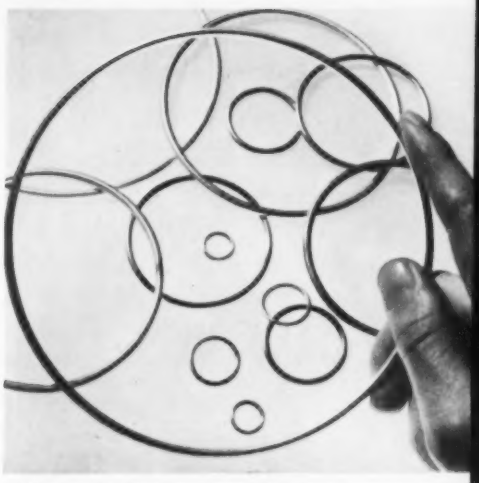
Stainless, Inc.

Towers — The high strength-to-weight ratio and uniform contour offered by welded carbon steel tubing make it possible to replace previously used structural angles and considerably reduce wind load problems. In addition, the tubing, which can be made either triangular, square or round, is lighter in weight and therefore cuts costs.

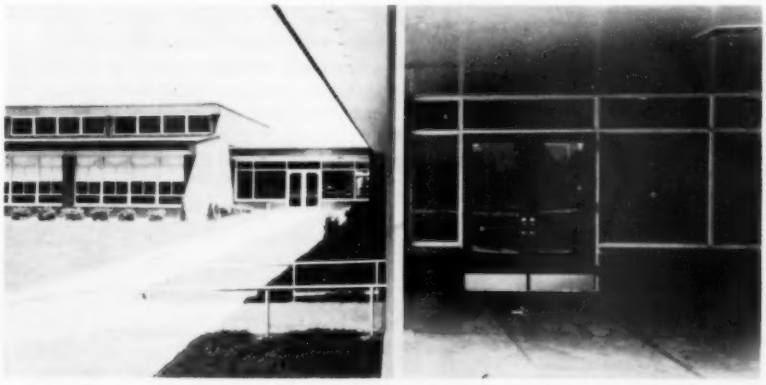
Atomics International, Div. of North American Aviation, Inc.

Casings and plugs—Uniform fit and corrosion resistance are the reasons given for the selection of welded stainless steel tubing for the casings and plugs used in the sodium reactor shown here. The extremely close tolerances and excellent finish obtainable were also major considerations.

Food conveyors—Welded stainless steel tubing is replacing copper, brass and glass tubing in many new food and beverage processing plants because it is easy to keep sanitary and is resistant to contamination by chemical reaction. About 80% of the tubing used in one dairy is cleaned in place (see photo) twice a day.



O-rings—Welded steel tubing is finding increased favor with designers as a basic o-ring material because 1) its high strength-weight ratio permits high pressures in small sizes and thin walls; 2) it is available in exact sizes; and 3) it requires little preparation for fabrication.



Construction—Welded steel tubing is becoming increasingly popular for columns, beams and curtain wall framing in building because, in addition to its structural advantages, the tubing (especially square or rectangular) adds to the beauty of the structure and is easily fabricated and joined to other materials.

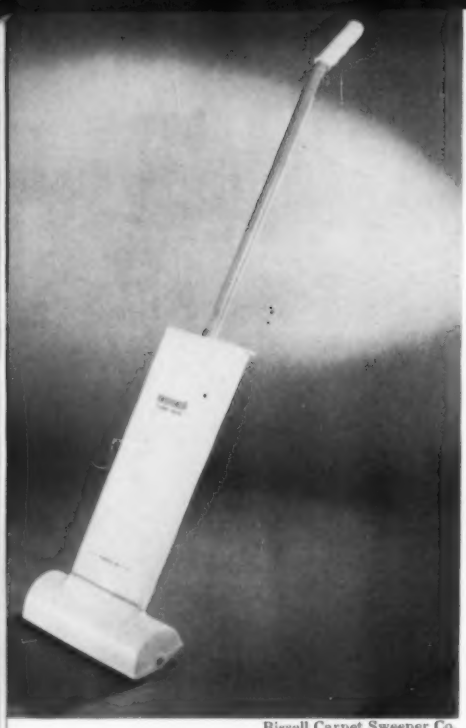
Heat exchangers—The ability to obtain uniform wall thicknesses was the deciding factor in the selection of welded stainless tubing for use in these heat exchangers. Welded carbon steels are also used, but stainless is specified where corrosion is a major factor.

Blaw Knox Co.

Hydraulic cylinders—The landing gear assembly on the F8U-1 plane uses welded steel tubing for the hydraulic cylinders because the material can be obtained with the exact finish required for the job.

Eight different plastics materials used in award-winning design

A unique liquid rug shampoo applicator, which uses eight different plastics for its 14 parts, was awarded first prize in the recent "Bachner Awards for excellence in the application of plastics." Three other entries—nylon roller skates, an ABS bathroom scale (see p 193), and foamed polystyrene drinking cups—were cited for honorable mention. Specific materials used in each design and the reasons for their selection are given in the captions for the accompanying photos.



Bissell Carpet Sweeper Co.

Shampoo applicator—*Housing:* molded of ethyl cellulose—dimensional stability, resistance to cleaning fluids, high impact and stress resistance; *distributor channel:* molded of polystyrene—low cost, ease of adhesive bonding; *gasket:* fabricated from vinyl sheet—provides lasting seal, is less costly than equivalent materials; *tank:* molded of polystyrene—impact resistance, can be stenciled, remains translucent in colors; *tank cover:* molded of polystyrene—easily adhesive bonded; *cap:* molded of vinyl—makes a good seal, can be integrally molded with a small retainer ring to go around handle; *trim:* metallized mylar—gives a metallic appearance; *protective coating for trim:* extruded vinyl; *roll shaft:* extruded polystyrene tubing—rigidity, resists fluid; *shaft bearings:* molded nylon—requires no lubrication, resists fluid; *roll:* urethane foam—only material tested that combines adequate sudsing with good wear resistance at reasonable cost; *brush bristles:* Saran—impervious to fluid; *handle:* molded vinyl—resists fluid, commercially available at low cost; *handle coating:* epoxy resin—prevents fluid from corroding steel.

Manning Mfg. Co.

Roller skates—Except for toe and heel straps, the skates are made completely of nylon. *Reason:* nylon is strong, requires no lubrication, and will not chip, peel, fade or discolor. Tests have shown that the nylon skates are superior to steel for ruggedness and durability. The skates are also light in weight and available in a variety of colors. The straps are of polyethylene.

Crown Machine and Tool Co.

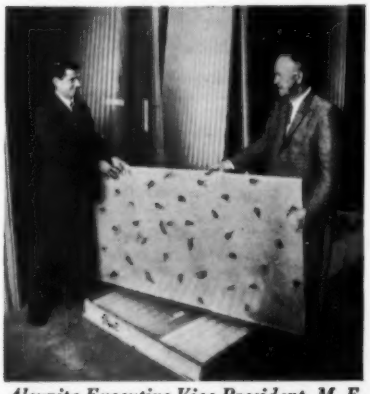
Drinking cups — The disposable cups, designed for hot or cold beverages, are fabricated from foamed polystyrene. *Reason:* the cups are light in weight (less than 3 gm), require no handles because the foam is an excellent heat barrier, impart no taste to the beverage, retain heat longer than conventional paper cups, and are competitive in price with paper cups.

MORE MATERIALS AT WORK

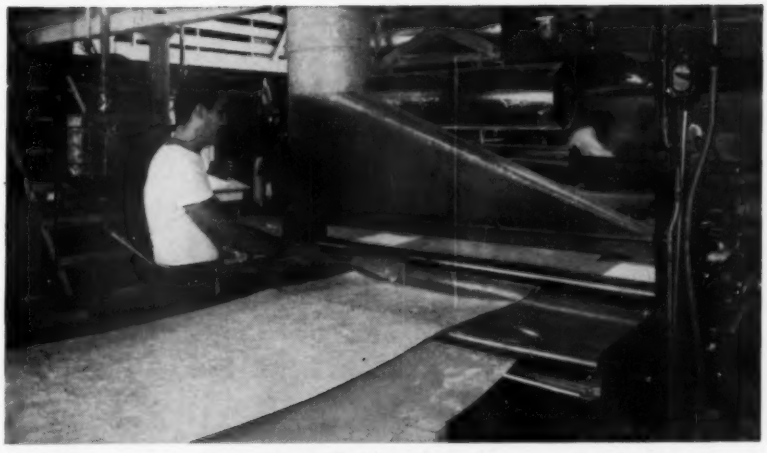
POLYLITE POLYESTER RESIN MEETS ALSYNITE UNIFORMITY STANDARDS— FROM BATCH TO BATCH

San Diego, Calif.—In extensive tests conducted by the Alsynite Company of America, manufacturers of reinforced plastic building panels, Reichhold POLYLITE Polyester Resins have met high standards for quality and uniformity.

Commenting on POLYLITE's test and production performance, F. X. Ambrose, Alsynite vice president for manufacturing development, said, "The resin we use must be adaptable to our specific processing methods — including such considerations as storage stability, properly controlled reactivity with the various catalysts and the highest degree of uniformity from batch to batch. Production records indicate that RCI resins have never let us down in the 3½ years we have been using them ... good justification, we think, for our confidence and continued association."



Alsynite Executive Vice President, M. F. McNeil, right, and RCI's Robert Swisher, District Sales Manager—Plastics, admire a finished Alsynite panel.



Pictured here is Alsynite employee, E. Alvarado, making sure that the glass fiber is properly impregnated with RCI POLYLITE Resin.

SCHEDULED DELIVERY

Alsynite, oldest and largest manufacturer in the field, uses extensive quantities of RCI POLYLITE Resins. A steady supply is assured Alsynite's three plants by fleets of 4,000-gallon tank trailers based at Reichhold plants in Azusa, Calif.; Detroit, Mich.; and Elizabeth, N. J. Regular, scheduled deliveries are made every two weeks, and the resin is stored for future use by Alsynite in 5,000-gallon outdoor, insulated storage tanks.

LEADER IN THE FIELD

In testifying to Reichhold's paramount position in polyester resins, Mr. Ambrose pointed out that the panels Alsynite produces must have outstanding color stability and high weather resistance ... and "our tests have consistently indicated that in insuring these properties, RCI polyester resins are among the tops in the industry."

COMPLETE RESIN LINE

If you are involved in production of glass reinforced plastics of any kind, you should investigate the complete line of RCI POLYLITE Polyester Resins — including fast curing lay-up resins, gel coats for spray, brush or roller application and any number of versatile general purpose polyester resins.

For further information and technical data write Reichhold for *Booklet B*. Reichhold Chemicals, Inc., White Plains, New York.

Smallest metal tubing

To the Editor:

The January issue, p 9, states that the smallest metal tubing made has a 0.050-in. i.d. and 0.115-in. o.d. with 0.010-in. wall. J. Bishop and Co. on p 165 advertises stainless steel tubing of 0.008-in. o.d. with 0.003-in. wall.

JAMES N. BUJAC, JR.
Idaho Falls, Id.

To the Editor:

The smallest tube in the world is only 0.0014-in. o.d., 0.0005 i.d. and 0.00045 wall. It was cold drawn by Superior Tube Co. from 2-in. dia. seamless nickel tubing. The lower limit of Superior's *standard* size range is 0.010-in. o.d.

DANIEL M. DAVIS
Philadelphia, Pa.

Item should have read "smallest flexible interlocking metal tubing."

Electrical insulation correction

To the Editor:

I am the author of "Electrical Insulation Materials," published in M/DE in Apr '57 as Manual No. 137. I recently had occasion to check the figures given for the coefficient of thermal expansion in Tables 10, 11, 13 and 14. I found a constant error running through all the figures. My original reference figures were in degrees Centigrade. In making the conversion to degrees Fahrenheit I apparently *multiplied* by 1.8 instead of *dividing* by 1.8. All of the figures in the tables should be divided by 3.24 (that is, 1.8 times 1.8) in order to correct them.

You may wish to correct any copies which you still have available for distribution. I have not found any other errors in the tables.

A. J. MONACK
Engineering Consultant
Rutherford, N. J.

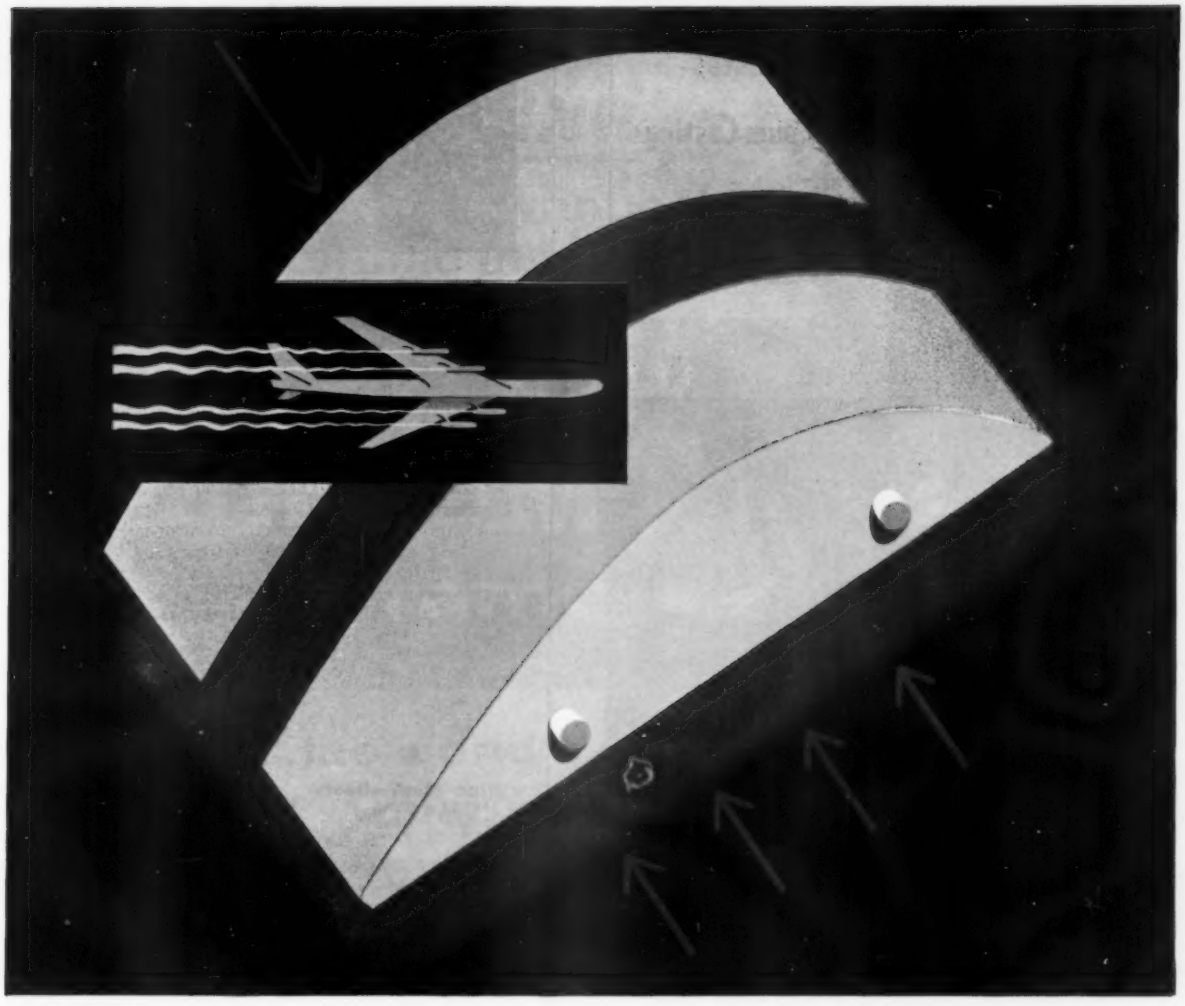
Remaining copies have been corrected and readers on our permanent manual reprint list have been notified.

Damping and brittleness

To the Editor:

I have never been able to accept orthodox thinking on the importance of damping as a materials property. If damping ability and brittleness could be reduced to a quantitative scale, they would be found to be a common property with brittleness and damping ability on opposite ends of the scale. Definitions and tradition tend to ensnare.

Mr. Thackery (Letters, Jan '59, p 14) suggests that brittleness is due to flaws of high stress caused



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High temperature tooling: Metal forming stretch dies that can operate at temperatures over 400°F.

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In addition, Epon resin formulations offer you the following advantages:

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by faulty heat treatment. This is the practical "brittleness" that causes failure, and it is a natural coincident that it accompanies high hardness. He seems to suggest that much higher hardness and strength would be safe if more perfect heat treatment were used. I agree with this and would like to extend the thesis to include a revision of the damping concept.

In support: 1) The balls and races of ball bearings have hardness of 65-63 R.. Brittleness and very low damping properties do not prevent high loads and long life. 2) Commercial springs with hardness of 44 R. loaded to very low safety factor give good service and excellent fatigue life. 3) Some light is shed on the subject by the method used to cut rails in olden days. We are told that a slight notch and a sharp blow with a hand sledge hammer did the trick.

A. C. STROTHER
Windsor, Conn.

Wide steel sheets

To the Editor:

In your Dec '58 issue, p 124, reference was made to the production of high strength sheet steel that measured 140 in. wide. It was claimed to be the widest sheet ever rolled.

In October, Lukens Steel Co. produced high-strength sheets that measured 160 in. wide for use in solid-fuel rocket engine casings. Because of Lukens' 206-in. rolling mill—the largest in the nation—only Lukens can produce sheets 160 in. wide and wider. The blue ribbon for width must accordingly be theirs.

SHELDON ZALAZNICK
The Manning Public Relations Firm
New York 21, N. Y.

Thank you for the information which is published here in lieu of blue ribbon presentation.

Properties of weldments

To the Editor:

The article "How to Select a Stainless Steel" in the January issue is a good resumé of the more salient features of the problem. However, the discussion on low temperature properties takes no cognizance of the effect of welding and heat treating. Too few people are aware that the limiting impact value is that of the weld and that its performance will vary depending upon composition and upon whether it is as-welded, stress-relieved or annealed. Also, in certain cases the performance of the heat-affected zone may become important.

C. P. DILLON
Materials Engineer
Union Carbide Chemicals Co.
Charleston, W. Va.

True, but the article covered properties of materials, *not weldments.*

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American Felt Company

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PRICES AND SUPPLY

...AT A GLANCE

Shipments of finished steel products were 20 million pounds lower in 1958 than in 1957—59.9 million net tons as compared to 79.9. According to the American Iron & Steel Institute, major shipments (millions of net tons) included: cold rolled sheets, 10.3; hot rolled sheets, 6.3; hot rolled bars, 5.6; plates, 5.3; electrolytic tin plate, 5.0.

Teflon 100-X FEP—Du Pont's new fluorocarbon resin—will be commercially available some time around November when a new plant is expected to be completed. According to Du Pont, the material will sell for $12 per lb. Present "development price" is $19 per lb. Uses for the new material include wire coatings, tubing, heat sealable film for bonding, and moldings.

World production of primary magnesium decreased in 1958 by about 35%, or from 156,000 tons produced in 1957 to 101,000 tons. According to the Bureau of Mines, most of the decline can be attributed to curtailed output in this country and in Canada: U. S. production in 1958 was down by about 62%; Canadian production was down by about 31%. U. S. consumption of magnesium ended up about 21% below that of 1957. Nearly half of this decrease is attributed to the sharp reduction in titanium production for which much magnesium is used.

More high density polyethylene will be available as a result of Monsanto Chemical Co.'s latest expansion which will increase its production capacity to 100 million pounds per year.

Prices of cobalt have been cut 25¢ per lb by African Metals Corp. New prices are: $1.75 per lb for 500-lb drums; $1.77 per lb for 100-lb lots; $1.75 to $2.70 per lb for fine metal powder; and $1.90 per lb for black cobalt oxide.

Domestic consumption of rubber in 1958 amounted to 1.4 million long tons as compared to 1.5 million long tons used in 1957. According to the Rubber Mfrs. Assn., use of synthetic rubber amounted to 873,000 long tons as compared to 926,000 in 1957. Natural rubber consumption amounted to 485,000 long tons as compared to 532,000 in 1957. Of the total, synthetic rubber usage accounted for 64.3%.

More steel will be available from Great Lakes Steel Corp. as a result of its latest expansion. According to Paul H. Carnahan, board chairman, the expansion will boost the company's annual production capacity from 3,700,000 tons to 4,200,000 tons, or by half a million tons. Emphasis in the new plant will be on semifinished steel.

Use of cellophane reached an all-time high in 1958, according to Du Pont. Total consumption is estimated at about 415 million pounds.

Platinum prices have started to increase now that Russian offerings have slackened. Two months ago the price was raised for the first time in more than two years. The latest increase, $10 per oz, brings the price to $77-80 per oz.

Production of refined lead in 1958 dropped to the lowest level since 1951. According to the Bureau of Mines, production amounted to 523,000 tons, or a drop of 81,000 from the 604,000 tons produced in 1957.

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First design clinic set for . . .

15th Annual MPI Meeting

April 20-22, 1959

The 15th annual meeting of the Metal Powder Industries Federation is set for Apr 20-22 at the Sheraton-Cadillac Hotel, Detroit. Running concurrently with the meeting is the 1959 Powder Metallurgy Show. A special event at this year's meeting is the first annual "Design Clinic for Powder Metallurgy."

The meeting

This year's technical sessions will feature 15 papers on various aspects of powder metallurgy and metal powder parts, and a special session on ceramic permanent magnets. Subjects to be covered at the meeting include: powder metallurgy of aluminum, continuous compaction of metal powders, bonding of cemented carbide to steel, automatic control of sintering atmospheres, new applications for powders, machinability of sintered iron, and methods for measuring the degree of sintering.

Technical sessions will run from 9 a.m. to 4 p.m. on Tuesday, Apr 21, and from 9 a.m. to 2 p.m. on Wednesday, Apr 22. The special session on ceramic permanent magnets will be held on Tuesday, from 9:15 a.m. to noon.

The complete program of the two-day technical meeting starts on this page. All technical sessions will be held in the hotel's Crystal Ballroom and Reception Room.

As in the past, business sessions and technical meetings of the various trade groups operating within the Federation will take place during the first day of the meeting, Monday, Apr 20.

A reception and banquet will be held Tuesday evening, Apr 21.

The clinic

The first annual Design Clinic for Powder Metallurgy is designed to give engineers, designers and management a first-hand opportunity to find out what is being done with powder metallurgy today and what advantages it may have to offer them. The clinic will consist of: 1) displays of the latest powder metallurgy structural components labeled according to application, properties and composition (technical people will be on hand to answer questions); 2) a package of literature giving specifications and other technical information; 3) an open forum discussion led by a panel of experts on all aspects of powder metallurgy; and 4) an opportunity to attend the 1959 Powder Metallurgy Show. Registration for the Clinic is free.

The show

Company exhibits will be open from 8:30 a.m. to 5:30 p.m. on Tuesday, Apr 21, and from 8:30 a.m. to 9 p.m., on Wednesday, Apr 22.

Exhibits will include new sintering furnaces, compacting presses, pulverizing mills and other equipment used in powder metallurgy. Various metal powders and fabricated parts will also be on display.

An alphabetical list of all companies exhibiting products at the Show appears on p 23.

Program

Monday, April 20

Registration
Business Meeting

Tuesday, April 21

8:30 a.m.
Powder Metallurgy Show exhibit opens

9:00 a.m.

Chairman—Charles E. Hanson, plastics Metals Div., National-U.S. Radiator Corp.

9:30—**New Method for Compacting Metal Powders Into Continuous Sections**—F. Emley and C. Deibel, Westinghouse Electric Corp.

10:00—**Use of Powder Metallurgy for Diffusion Bonding of Cemented Carbide to Steel**—J. F. Kuzmick and G. B. Goodfellow, Powder Alloys Corp.

10:30—**Some New Applications of Lead Powder**—R. L. Ziegfeld, Lead Industries Assn.

11:00—**Metal Powders In Concrete**—S. V. Wilson, U. S. Bronze Powder Works.

9:15 a.m. Special session on Ceramic Permanent Magnets

Chairman—Christopher L. Snyder, General Ceramics Corp.

9:15—**Magnetic Torque Couplings Utilizing Ceramic Permanent Magnets**—R. W. Young, Stackpole Carbon Co.

10:00—**Power Ferrites in the Industrial Field**—B. Budney, Allen-Bradley Co.

10:45—**Permanet Magnet Motors—Factors in the Application of Ceramic Magnets**—R. Scholten, Indiana Steel Products Co.

2:00 p.m.

Chairman—Byron Belden, Baldwin-Lima-Hamilton Corp.

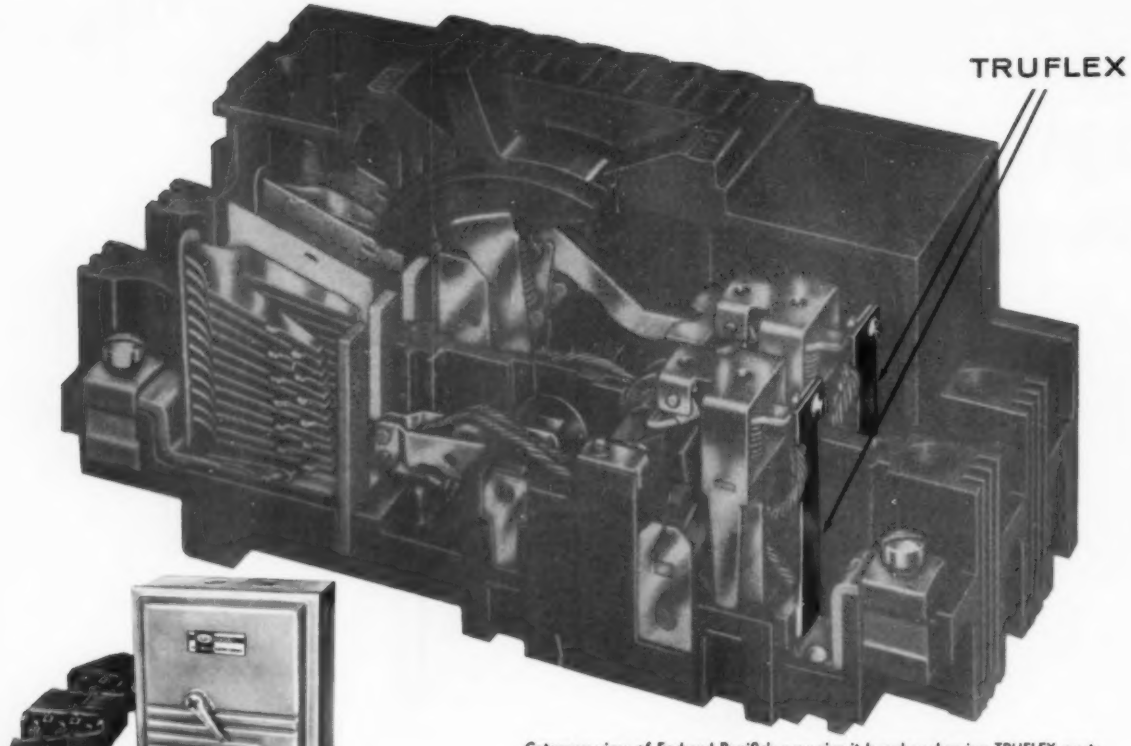
2:00—**The Effects of Lithium Stearate Additions and Various Atmospheres on Sintered Brass Compacts** — F. Zaleski, Frankford Arsenal, and R. Powell, Pitman-Dunn Laboratory

2:45—**Automatic Control of Endothermic Sintering Furnace Atmospheres,** G. F. Sommer, Link-Belt Co.

3:30—**Direct Particle Size Measurement of Superfine Metal Powders,** J. Haertlein, Metals Disintegrating Co.

4:00—**Fundamentals of Powder Metallurgy Lecture: Detergency in Powder Metallurgy** — A. J. Shaler, Pennsylvania State University.

(cont'd on p 23)



Cutaway view of Federal Pacific's new circuit breaker showing TRUFLEX parts.

Truflex®

Federal Pacific Chooses Thermostat Metal Assemblies for new Circuit Breaker

In designing its AB circuit breakers, Federal Pacific Electric, like more and more manufacturers, turned to General Plate for TRUFLEX Thermostat Metal Assemblies. Here's the reaction of C. A. Schmidt, Manager of Federal Pacific's Products Department:

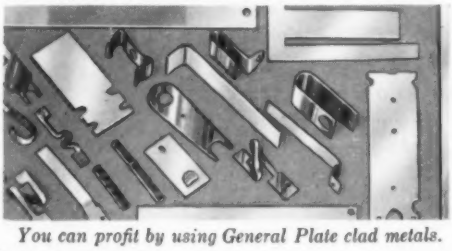
"The TRUFLEX *Thermostat Metal Assemblies in our new AB breaker equipment have more than proven their dependability and we are more than satisfied with the performance of these* TRUFLEX *components."*

General Plate manufactures these TRUFLEX Assemblies to Federal Pacific's exacting specifications and every piece is a duplicate of the original. Today General Plate makes TRUFLEX parts and assemblies for hundreds of manufacturers who have found that TRUFLEX means better control, indication and compensation of temperature in a wide range of products.

Here's why:

- **Truflex parts** and assemblies are engineered to your specifications — made with precision and uniformity, ready for installation.
- **This eliminates** the need for you to carry out prolonged experimental work and provide special manufacturing equipment. Expensive calibrating operations are not necessary when you use TRUFLEX parts.
- **If you prefer** to make your own parts, TRUFLEX metals are available in extra long coils or flat strips manufactured to exact specifications.

A few typical TRUFLEX *formed parts and sub-assemblies*



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POWDER METALLURGY PREVIEW *concluded*

6:30 p.m.
Reception and Banquet

Wednesday, April 22

8:30 a.m.
Powder Metallurgy Show exhibit opens

9:00 a.m.

Chairman — Robert C. Burgess, Burgess-Norton Mfg. Co.

9:00—**The Production of Sintered Aluminum Compacts**—C. Brooks, Reynolds Metals Co., and S. Bradbury, F. H. Stokes Corp.

9:45—**A New Basis For Measuring the Degree of Sintering of Sintered Compacts**—B. Bovarnick, Rodman Laboratory, Watertown Arsenal

10:30—**Machinability of Sintered Iron Compacts** — R. Jamison, Hoeganaes Sponge Iron Corp.

2:00 p.m.

The advancement of Powder Metallurgy Applications In the Automobile—R. Blue, Amplex Div., Chrysler Corp.

Exhibitors

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Don't miss the *must* event of the year for everyone connected with product design, research and development.

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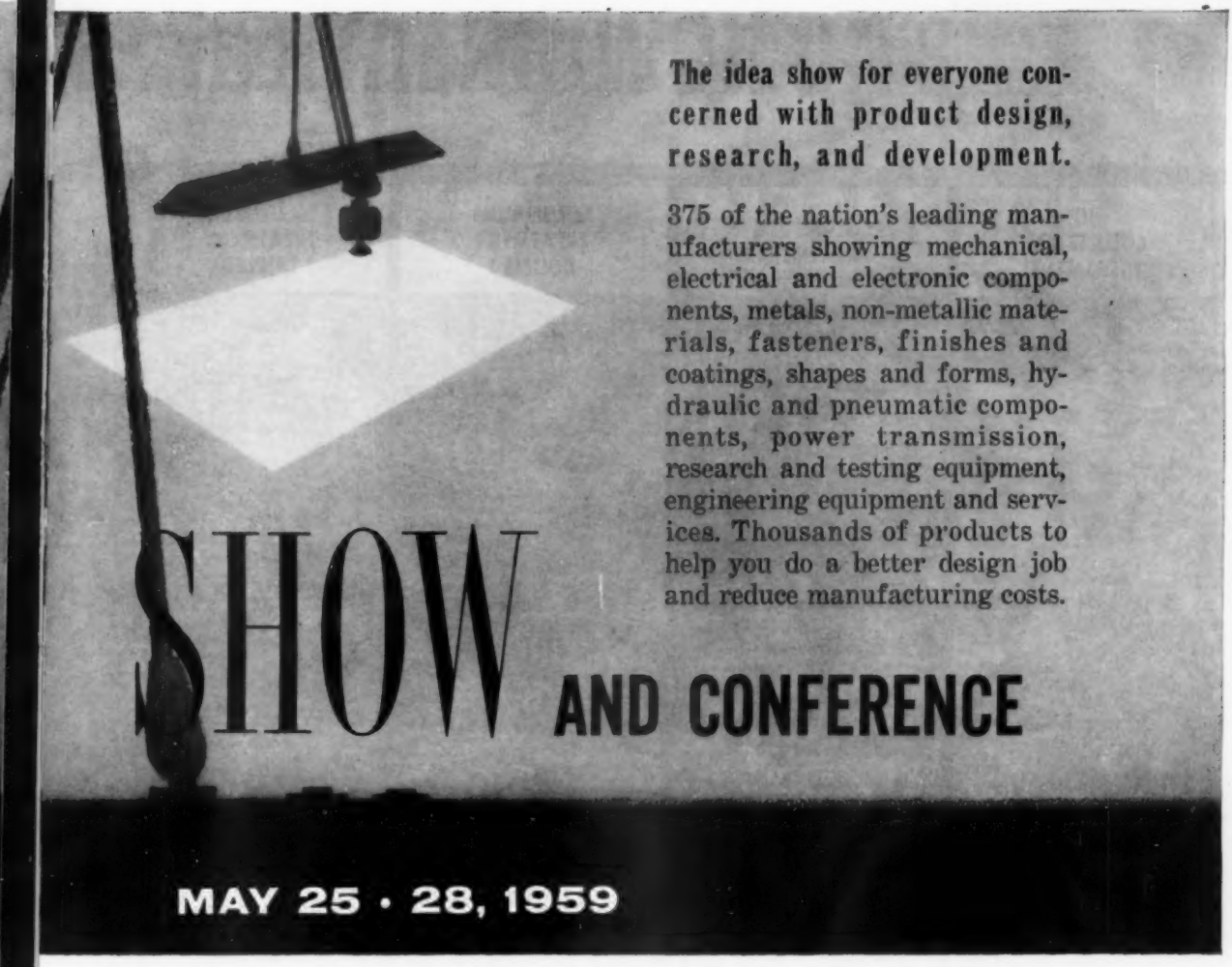


The idea show for everyone concerned with product design, research, and development.

375 of the nation's leading manufacturers showing mechanical, electrical and electronic components, metals, non-metallic materials, fasteners, finishes and coatings, shapes and forms, hydraulic and pneumatic components, power transmission, research and testing equipment, engineering equipment and services. Thousands of products to help you do a better design job and reduce manufacturing costs.

SHOW AND CONFERENCE

MAY 25 • 28, 1959

ACTION DEMONSTRATIONS
Exhibits feature working models, cut-aways, technical illustrations — to bring you as close as possible to the product story.

ENGINEERING PERSONNEL
Bring your blueprints. Exhibitors staff their booths with engineers. They can help engineer your problems on the spot.

PERFORMANCE TESTING
Wherever possible, products will be subjected to performance tests to prove to you, in person, their capabilities.

CATALOGUES AND TECHNICAL LITERATURE
Hard to obtain technical data is available at the source. Exhibitors make available to you their published data in one place — at one time.

PRODUCT APPLICATIONS
Exhibitors in this show concentrate on displaying imaginative applications of their products to suggest design solutions.

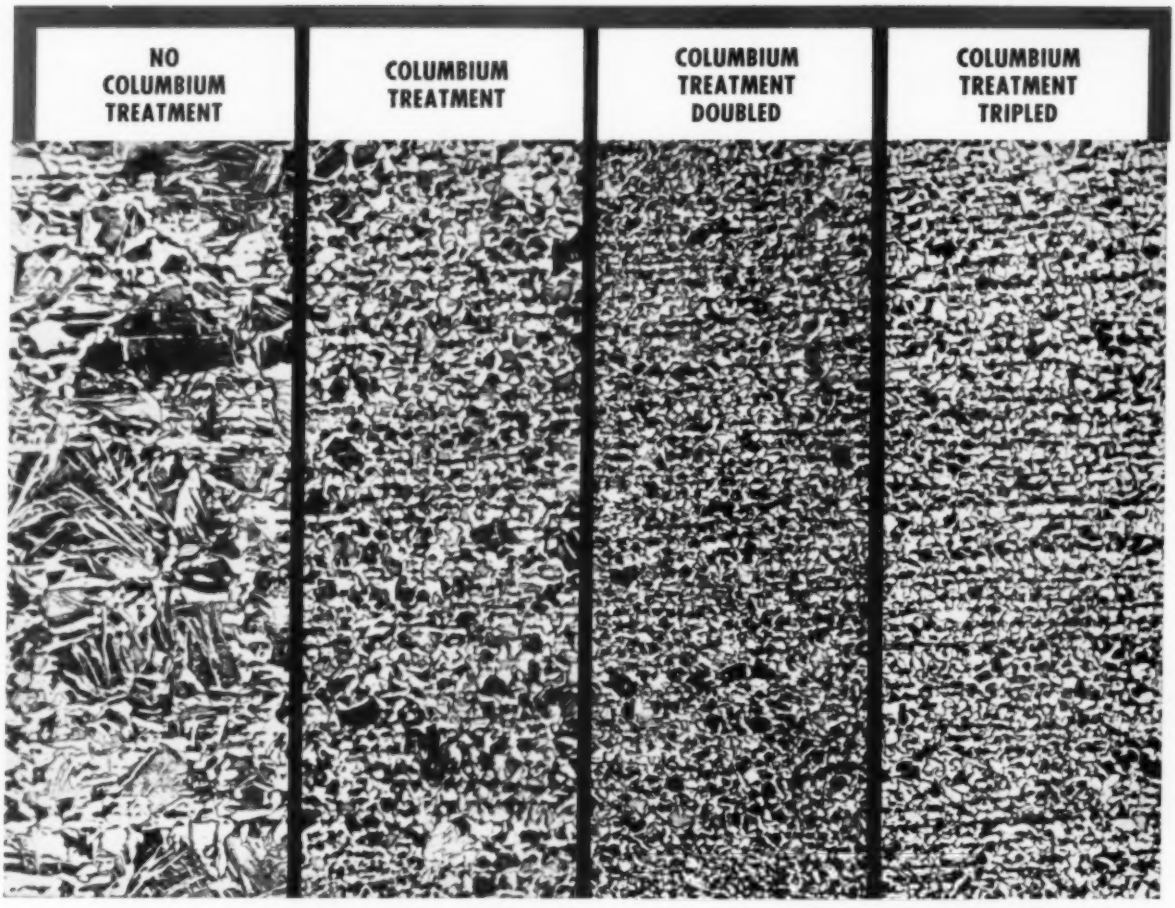
NEW SOURCES
Within the ranks of some 375 exhibitors, you'll find new sources of supply for materials, products, components, and services you require.

PRODUCT COMPARISON
Check competitive claims immediately by going from one booth to another.

SAMPLES
Take home for trial and test actual samples of products you're interested in. Most often they're available in exhibitors' booths.

IDEAS
Your eyes will be opened to thousands of applications, suggestions, demonstrations, that can spark new thinking — speed your designs to a successful conclusion.

HOW GREAT LAKES



Composite of photomicrographs made from the same heat of mild carbon steel shows the effect of varying columbium treatments on the grain structure of the steel.

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N-A-X FINEGRAIN STEEL

Lets you design superior performance, longer life and less weight into your product. Many diversified applications.

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Offers all the characteristic features of N-A-X Finegrain, plus greatly enhanced resistance to atmospheric corrosion.

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Quenched and tempered steels of excellent weldability and toughness, with yield strengths from 75,000 - 110,000 psi.

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N-A-X High Manganese and High Manganese Special Killed. These steels give yield strengths up to 50,000 psi.

STEEL CORPORATION'S NEW GLX-W STEELS GIVE ... HIGH STRENGTH TOUGHNESS REDUCED COSTS

Key to the success of Great Lakes' new GLX-W Series of steels is the fine grained internal structure produced by treatment with columbium. This grain refinement also contributes to ductility. And in addition, the GLX-W Series' low carbon and manganese content assures excellent weldability with freedom from underbead cracking under all conditions.

COST AND WEIGHT SAVINGS

Where design permits the replacement of carbon steel with GLX-W steels, weight savings of 20 to 35 per cent, and cost savings of 10 to 25 per cent can be realized. When replacing alloy steels the cost savings can range from 25 to 35 per cent. These steels feature higher yield strengths, greater tensile strengths and increased toughness without costly heat treatments or extensive alloy additions.

The GLX-W Series is so priced that substantial cost reductions can be obtained by weight reduction over mild carbon steel. Cost reduction can also be obtained over alloy steels because of the lower price of GLX-W steels.

MANY USES FOR GLX-W STEELS

GLX-W steels are especially recommended for a broad range of applications in mobile equipment and pressure vessels, as well as the transportation and construction fields.

STRONGER AND TOUGHER

GLX-W steels are stronger and tougher than ordinary mild carbon steels and in some applications can do the job now being done by the more costly alloy steels.

GLX
W

For additional technical information about these economical GLX-W steels write

Product Development Division, Dept. D-1

GREAT LAKES STEEL CORPORATION

Detroit 29, Michigan • Division of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 452

DOW | MAGNESIUM

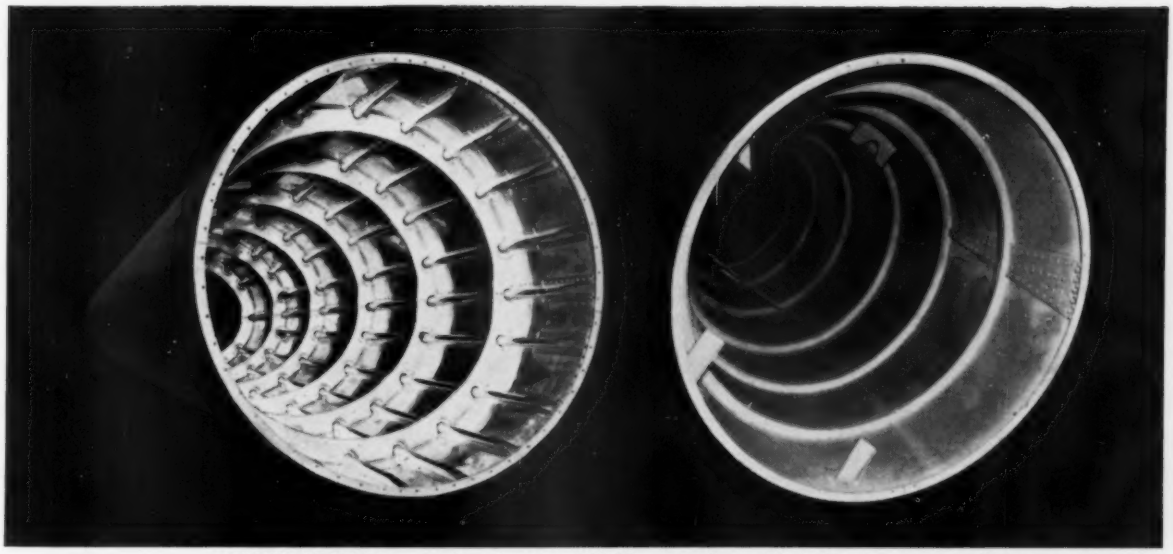
LIGHTWEIGHT DESIGNS

save more than weight

Designers reap a rich harvest of additional benefits as a result of lightness when they use magnesium. Bonuses such as more payload, simplified design, increased performance and reduced human exertion.

People who buy and use the luggage pictured above derive a very direct benefit from magnesium. As this lightweight luggage is made of magnesium, it saves human effort and fatigue. Also, the reduction of weight means more luggage can be carried without extra charge when traveling by air. Magnesium saves human exertion in other products, such as ladders, power tool housings and materials handling equipment.

Another example of the many savings and extra benefits that magnesium —and its resultant load lightening make possible for the designer is in the automotive field. One delivery truck unloads its last parcel and heads for the garage and the gas pump. Another, of identical size, goes on to deliver many



SIMPLIFIED DESIGN in magnesium aircraft part (right) was made possible by its advantageous stiffness-to-weight ratio.

more lbs. of merchandise. Why? The second truck is much lighter—its body is made entirely of magnesium alloy sheet, plate and extrusions. *Because* the second truck is lightweight, it can carry more payload. Or, it can carry the same payload as the first with less fuel, smaller tires and less wear and tear on the engine and transmission. Lighter trucks also save their owners money on license fees, insurance premiums and over-all maintenance.

An even more dramatic example is that of missile design. In one ballistic missile, the elimination of *one pound* of excess weight contributes approximately 18,000 feet of additional altitude and a comparable increase in range! This means vastly improved performance wherever magnesium can be substituted for heavier materials.

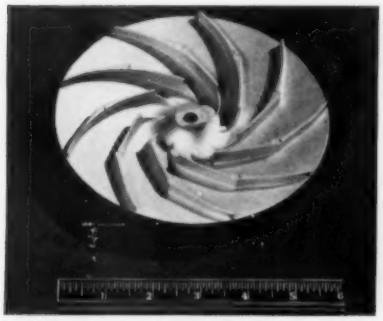
MAGNESIUM LIGHTNESS INCREASES STRENGTH, STIFFNESS

The designer who is seeking a stiff section can achieve it easily—and still save weight—with magnesium alloys. Magnesium weighs only 67% as much as aluminum, 25% as much as steel and zinc. A structure made of magnesium could be 8 times as stiff as the same part in steel if designed to equal weight. If equal stiffness is the design criterion, a magnesium section can weigh 62% less than steel and 25% less than aluminum.

Aircraft manufacturers have learned to exploit these facts to the fullest in conserving precious airborne weight. Critical parts such as wing and tail structures can be designed with more than adequate stiffness for high speed flying conditions. And, in addition to weight savings, magnesium helps provide a smooth aerodynamic surface and reduces "flutter" and "drag". Most important, the use of more rigid magnesium sections simplifies design by eliminating many of the stringers and stiffeners necessary with other materials.

★ ★ ★

WRITE TODAY for new brochure, "Magnesium Design". For your copy of this valuable reference for designers, contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Sales Department 1340CD 4.



22,000 r.p.m. HOUSEHOLD ITEM

This die cast vacuum cleaner fan must rotate at 22,000 r.p.m. and have low starting inertia as well as high centrifugal strength. Only magnesium was able to meet the requirements of this specific design. Casting tolerances are held so closely there is no need for balancing.

WORKER FATIGUE THWARTED

A prominent automotive manufacturer uses magnesium paint shields in spraying speedometer panels. The weight saving compared to previous shields resulted in less fatigue, higher efficiency for women employees. The excellent alkali resistance of magnesium permits easy removal of dried paint.

PRODUCTION FACILITIES

Excellent production facilities, maintained by Dow and other manufacturers, are located throughout the nation. These firms are well equipped to provide castings, mill products, fabrications and related production services which effectively utilize magnesium's inherent advantages.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

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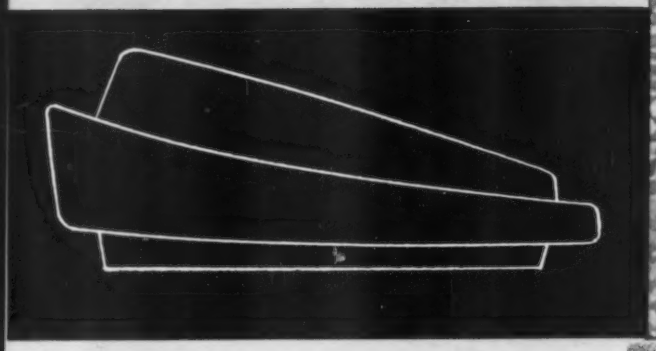
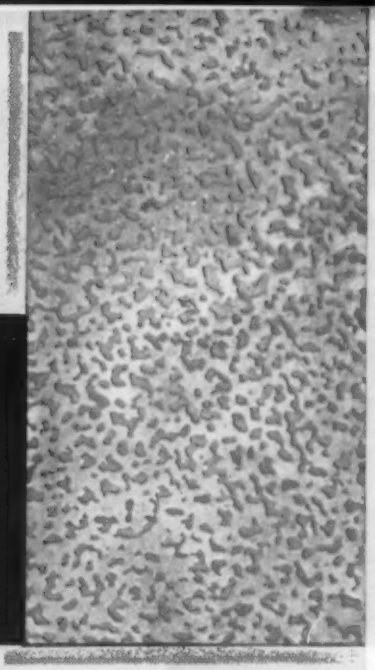
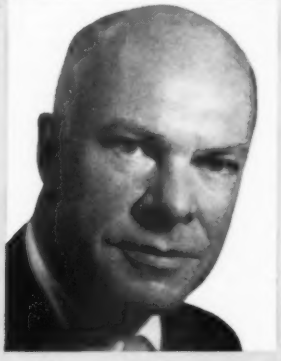




Peter Schladermundt, A.I.A., A.S.I.D., P.D.C., for 25 years a leading designer of many of America's foremost industrial products. Formerly associated with Norman Bel Geddes and other designers and architects on such projects as General Motors "FUTURAMA" and the design of Rockefeller Centre. Presently heading his own firm specializing in all types of design service to industry. Recently designed the Trade Fairs for the United States Government Department of Commerce in Milan and Paris.



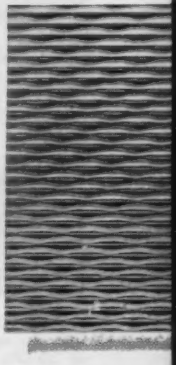
Peter Schladermundt and Sharonart combine for a new design concept..

Tomorrow's business machines will have the low, sleek profile and functional beauty you see in this typewriter design created by the nationally known industrial designer Peter Schladermundt especially for the Sharon Steel Corporation.

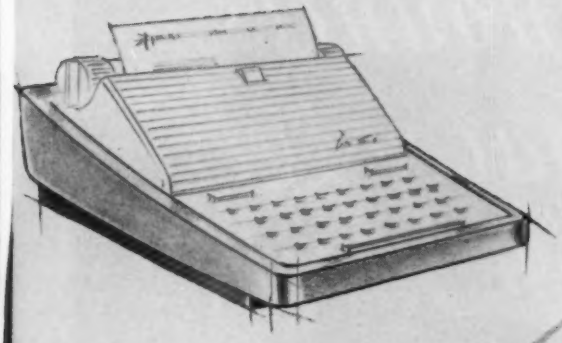
Gone is the bothersome cloth cover and in its stead a regular built-in secretarial workshop that includes typewriter accessory and lighted shorthand book and note compartments. And when the day is through the desk area is made neat by simply dropping the attractive machine lid.

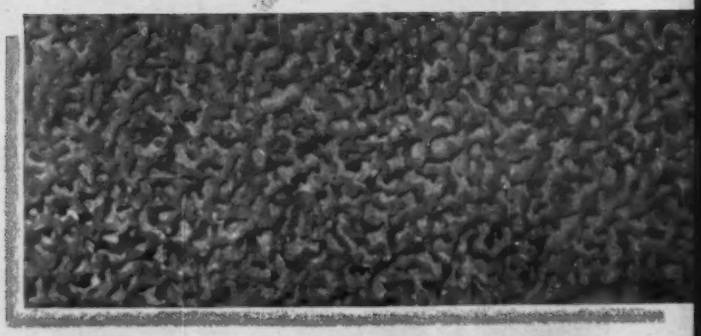
Ingenious? Yes, but perhaps the most important aspect of the design is the functional use of Sharonart, Sharon's popular patterned steel. By fashioning the work areas of Sharonart the usual marks of wear never show, and by forming the cover of this amazing metal many styles are immediately available to the manufacturer by simply changing the pattern . . . and here, too, wear is practically eliminated.

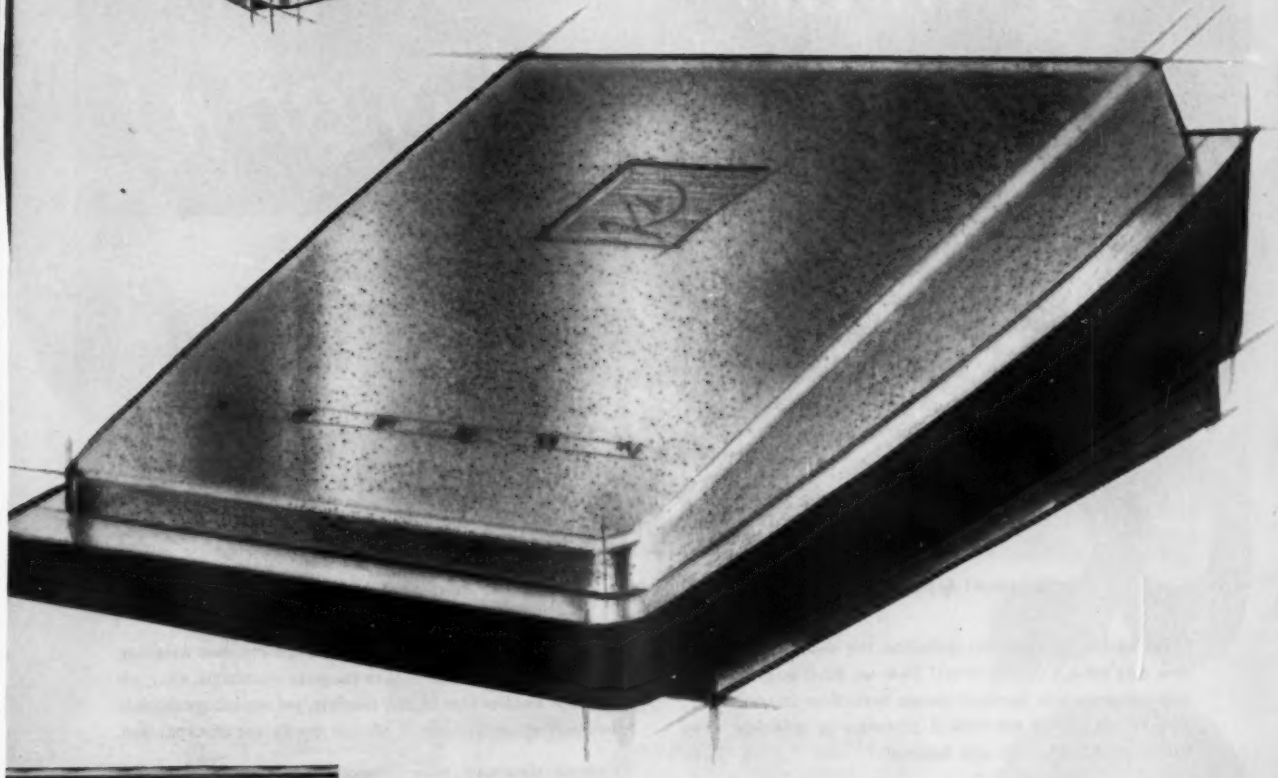
It's the kind of forward thinking that has made Sharonart the most popular material of its kind. Literature and information available from the Sharon salesman in your area or by writing direct to *Sharon Steel Corporation, Sharon Pa.*

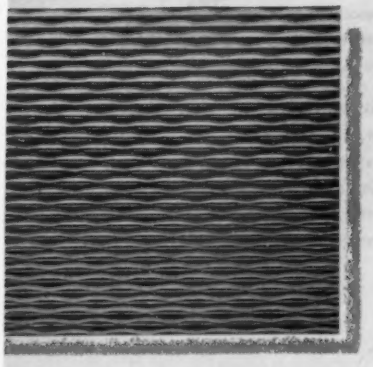


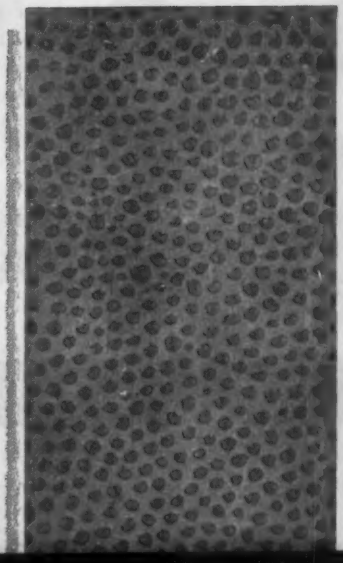
SHARONSTEEL **SHARON** *Quality* **STEEL**











Fansteel Announces the First Space-Age Breakthrough in the Fabrication of Tungsten!

Tungsten! *By Deep Drawing!*

Tungsten! *By Spinning!*

Once again, Fansteel has unlocked the door to unlimited new uses for a valuable metal! Now we have ways to fabricate tungsten into involved shapes heretofore impossible . . . and through such economical processes as spinning, deep drawing, hot extrusion and forging!

Now . . . tungsten—with its melting point of 6152°F., highest of all metals, its terrific strength at high temperatures, its outstanding density of .697 lbs./cu. in.—can be exploited to the fullest. Great advances can now be made in the fields of missiles, nucleonics, aviation, medicine . . . even consumer products. Fansteel has broken through to the secret of fabricating tungsten . . . its potential is now unlimited.

Imagine rocket nozzles with tungsten's fabulous heat/strength properties. Or a tungsten-encased atomic power plant weighing just five pounds. Picture a pure tungsten gyroscope rotor, almost 25% smaller than is now possible, yet retaining complete functional reliability due to its low coefficient of expansion.

Tungsten electronic tube components, tiny wristwatch flywheels and thousands of other applications are now also feasible with Fansteel's tungsten fabrication know-how.

This revolutionary knowledge is so new that we can't supply bulletins, technical information, or other printed data. But our engineers will be glad to cooperate with your own designers and production people in adapting tungsten and these new fabricating techniques to your part or product. Just send print, part samples or call in the Fansteel representative.

FANSTEEL

HIGH TEMPERATURE METALS

K592

FANSTEEL METALLURGICAL CORPORATION, NORTH CHICAGO, ILLINOIS, U. S. A.

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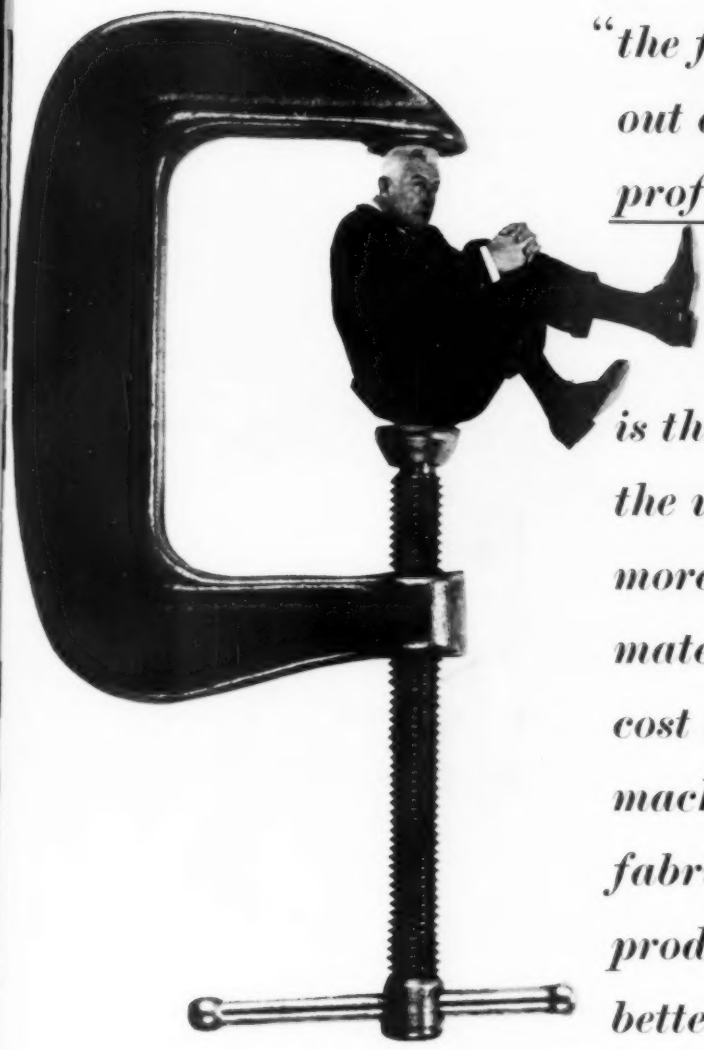


"the fast way out of today's profit squeeze

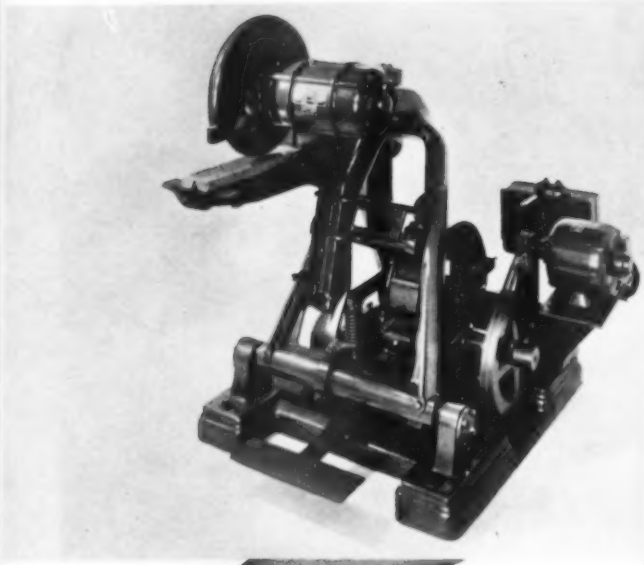
is through the use of more efficient materials which cost less to machine and fabricate, yet produce a better product..."

i.e. Federated Tenzaloy the high-strength aluminum alloy that needs no heat treatment

ASARCO

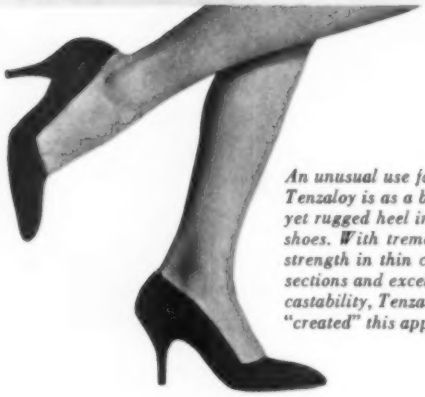
SEE NEXT PAGE

Federated TENZALOY



The vibration, strain, and abuse undergone by the movable arm of this cut-off saw calls for Tenzaloy, more and more the most qualified material for hard usage applications of this type.

Tenzaloy replaced a more expensive alloy in casting this airplane turntable when increasing size and weight of today's planes required a casting so large (4000 pounds!) that no heat treating equipment could handle it.



An unusual use for Tenzaloy is as a beautiful yet rugged heel in women's shoes. With tremendous strength in thin cross sections and excellent castability, Tenzaloy "created" this application!

Today's cooks choose shiny lightweight utensils cast in Tenzaloy over old style cast-iron pieces which often left ugly rust streaks. With corrosion-free Tenzaloy, there's no chance of contamination—ever!

Corrosion engineers expect these New York street signs to stay rust-free and shiny for years. In fact, they are unconditionally guaranteed maintenance-free for 15 years!

Tenzaloy contributes great strength in thin cross sections to these handsome modern chairs. Its castability in single-piece complex shapes, opens up wide new possibilities for the furniture designer.

e self-aging aluminum alloy gives you castings with greater strength–

Unlike heavy old-style fixtures, awning hardware cast in lightweight Tenzaloy defy rust and outdoor wear. No painting needed; the bright finish is permanent!

for less! Tenzaloy the self-aging aluminum alloy needs no heat treatment! If your aluminum castings are too large or too intricate for heat treatment, if your heat treating facilities are limited, if you need superior strength than you get from ordinary heat-treated alloy, specify "Federated Tenzaloy" developed by Federated to meet the need for a superior aluminum alloy that ages at room temperature. Tenzaloy eliminates rejects due to warpage, expansion, and internal stresses caused by quenching. Tenzaloy finished properties are stable, proved by conclusive test data over a ten-year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand cast and plaster molds and many permanent molds. Tenzaloy will not "grow," produces corrosion-resistant castings with excellent polishing characteristics and anodizes clear white.

Specify Federated Tenzaloy for:

1. High "as cast" properties—no heat treatment required to get the properties of heat-treated castings.
2. High yield strength—Tenzaloy can be stressed beyond other high-strength, non-aging alloys.
3. Excellent ductility, particularly before aging—if it is desired to cold work or form castings, it should be done as soon as possible after casting, preferably within a day or so.
4. High impact and shock resistance.
5. Excellent machinability—better than the common aluminum-copper alloys. Machinability maximum after aging several weeks, or after artificial aging at 250°F. If machine operations are performed too soon after casting, some tendency to gumminess will be experienced.
6. Superior corrosion resistance—equivalent to the aluminum-silicon alloys.
7. Excellent polishing characteristics—will produce silvery-white castings that take a high polish.
8. Takes a white anodized finish—castings can be dyed all available colors; porosity-free surfaces are essential for satisfactorily utilizing current commercial dyeing procedures.
9. No special foundry technique required—handles like any other aluminum alloy. Heat to required temperature, skim and cast. Magnesium additions normally not required.
10. Good castability—produces sharp impressions, clean castings.
11. Permanent molds can be used—thin-walled, restrained, intricate shapes should be avoided.
12. Plaster molds can be used—properties superior to other aluminum alloys will be obtained. Excellent castability.
13. No fluxes needed—skimming alone is sufficient. A flux may be used to assist in dross removal where necessary. All stirring and excessive turbulence during pouring should be avoided.
14. Dimensionally stable—Tenzaloy does not grow as do other aluminum alloys containing copper and silicon as major alloying elements.
15. Internal stresses normally found in high-strength heat-treated castings are not present because quenching is not required.
16. Can be brazed by standard techniques used for wrought alloys; oven or flux-dip method.

COMPOSITION AND COVERING SPECIFICATIONS

The nominal composition of Tenzaloy is: Copper—0.8%, Zinc—8.0%, Magnesium—0.4%, Aluminum—balance.

Tenzaloy is covered by SAE 315, ASTM Specifications B179-58 alloy ZC81A-B for Ingot; B108-58T alloy ZC81B for Permanent Mold: and B26-58T alloy ZC81A for Sand Casting. Tenzaloy is covered in Government Specifications by MIL-A-17129 (Ships) Class 8, MIL-A-12033 (ORD) alloy ZC81A, and Federal Specification QQ-A-6016 Class 22M.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

Ready to talk TENZALOY?

(or about any one of the many others of Federated Metals' complete line of aluminum casting alloys)

Write for Tenzaloy Bulletin No. 103, Aluminum Casting Alloys Handbook Bulletin No. 101. Federated Metals Division, 120 Broadway, New York 5. Or the Federated Sales Office, or plant near you

ALTON, ILLINOIS
Alton Phone: Alton 5-2511
St. Louis phone: Jackson 4-4040

BALTIMORE 24, MARYLAND
Highland & Eastbourne Aves.
Phone: Orleans 5-2400

BIRMINGHAM, ALA.
416 Dalton Drive
Phone: Fairfax 2-1802

BOSTON 16, MASS.
Statler Office Bldg.
20 Providence Street
Phone: Liberty 2-0797

CHICAGO, ILL. (WHITING)
123d St. & Indianapolis Blvd.
Chicago phone: Essex 5-5000
Whiting phone: Whiting 826

CINCINNATI, OHIO
1603 Carew Tower
Phone: Cherry 1-1678

CLEVELAND, OHIO
Hanna Building
1422 Euclid Avenue
Phone: Prospect 1-2175

DALLAS, TEXAS
Phone: Adams 5-5034

DETROIT 2, MICHIGAN
522 New Center Building
7430 2nd Avenue
Phone: Trinity 1-5040

EL PASO, TEXAS
1213 Mills Building
(Asarco Mercantile Co.)
Phone: 3-1852

HOUSTON 29, TEXAS
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P.O. Box 24038
Phone: Orchard 4-7611

LOS ANGELES 23, CALIF.
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Phone: Angelus 8-4291

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4608 West Burleigh St.
Phone: Hilltop 5-7430

MINNEAPOLIS, MINN.
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Newark phone: Mitchell 3-0500
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1336 Phila. Nat'l Bank Bldg.
Broad & Chestnut Sts.
Phone: Locust 7-5129

PITTSBURGH 24, PENNA.
615 Gross Street
Phone: Museum 2-2410

PORTLAND 9, OREGON
1900 N.W. 18th Avenue
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123d St. & Indianapolis Blvd.
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Chicago phone: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd.
Toronto, Ont., 1110 Birchmont Rd. Scarborough, Phone: Plymouth 7-3246
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FEDERATED METALS DIVISION OF
American Smelting and Refining Company, 120 Broadway, New York 5, N.Y.

ASARCO

Accurate Springs **seal the goodness in**

Accurate Spring Mfg. Co., Chicago, Ill. depends on Keystone Wire for millions and millions of springs that go into manufacture of "Reddi Wip" cans.

Mrs. Housewife takes it as a matter of course that when she presses the nozzle on a can of "Reddi Wip" whipped cream, out will come the proper amount of delicious whipped cream. The manufacturers of these modern dispensers have made sure that this is exactly what happens, by designing a small spring which functions flawlessly in this application.

Accurate Spring produces millions of these springs from Keystone Brite MB Spring Wire. This high production run of precision springs is dependent on absolute uniformity of the wire.

Experienced appraisal and prompt solution to your wire problems is a Keystone specialty. *This service can be yours by contacting your Keystone Representative today!*

Keystone Steel & Wire Company, Peoria 7, Illinois

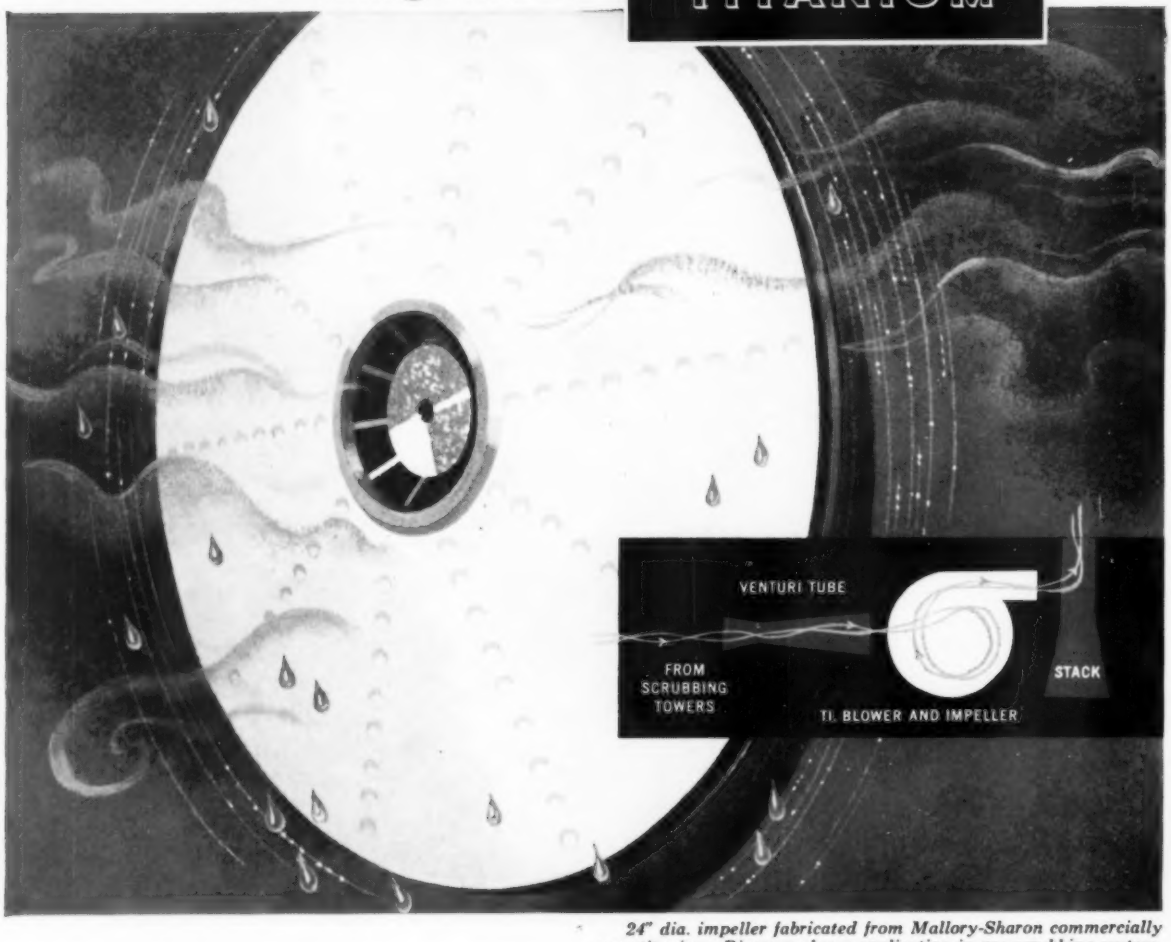
This spring must have exactly the right degree of stiffness, yet flex easily and have "sales-appeal" appearance. Keystone Wire meets these strict requirements for uniformity, correct resiliency and good plating quality.

KEYSTONE MB SPRING WIRE WIRE STUDY

KEYSTONE

WIRE FOR INDUSTRY

Cost cutting ideas in **TITANIUM**



24" dia. impeller fabricated from Mallory-Sharon commercially pure titanium. Diagram shows application in gas scrubbing system.

TITANIUM IMPELLER PROVED "BEST BY TEST"

...outlasts other metals more than 40 to 1

CORROSION TEST DATA
Results after 16-day exposure

MATERIAL	CORROSION RATE INCHES YEAR	COMMENTS
Pure Titanium	0.0006	No visual effect
Pure Zirconium	0.027	Slight pitting
Nickel-Base Alloy "A"	0.052	Slight uniform corrosion
Nickel-Base Alloy "B"	0.206	Sample etched
Nickel-Base Alloy "C"	0.217	Sample etched
Nickel-Base Alloy "D"	5g.	Sample consumed
300 Series Stainless "A"	0.442	Sample deeply etched
300 Series Stainless "B"	0.510	Sample deeply etched
Nickel-Copper Alloy	50g.	Sample consumed
Nickel	55g.	Sample consumed
Metallic Silver	20%	Gain in Weight

Approximate conditions of test: *Temperature–40° to 90°F., Humidity–atmosphere more than saturated. Primary corrosive agents–Hypochlorous acid, Hydrochloric acid, Sodium Hypochlorite, Caustic Soda, Free Chlorine.*

A leading chemical company faced a serious problem in a multi-metal chloride "gas scrubbing" system. The system's high-velocity blower, handling corrosive wet gases at 40° to 90°F., operated at 3500 rpm. Peripheral speeds were too high to use a plastic coated steel impeller. When one was tried, it lasted just two days.

Titanium was then considered with other metals, and evaluation tests run that proved titanium was by far the best. (See test results at left.) An impeller fabricated from Mallory-Sharon commercially pure titanium was installed. To date, it has given *10 months' continuous service* and is still in use. And *the original cost was no more* than for a nickel-base alloy impeller.

We'll gladly help you in applying titanium for highly corrosive service. For further information, write for "Cost Cutting Ideas in Titanium for Chemical Pumps, Valves and Accessories". Address: Commercial Market Development, Dept. B, Mallory-Sharon Metals Corp., Niles, Ohio.

MALLORY MS SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

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Tool Steel Topics

BETHLEHEM STEEL

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BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Lehigh H makes deep draw... passes test with flying colors

It takes a deep draw to form these cone-shaped lamp shades from .025 in. steel sheet at Keystone Lamp Manufacturing Co., Slatington, Pa. The forming die frequently gave trouble, causing production to bog down.

The lamp maker contacted Luria Steel Supply Co., a distributor of Bethlehem tool steel. "We know the job is difficult," they said, "but perhaps you can tell us about a tool steel that will withstand such a deep draw."

The Luria representative had seen such problems before. "I'd recommend Lehigh H," he told them. "I've seen it handle plenty of tough applications. It has all the stamina you need for this job, and then some."

The Lehigh H die, hardened to Rockwell C60, performed just as he said it would. It had high surface hardness to prevent pickup and galling. Because of its high wear-resistance, it averaged 200,000 shades, a substantial increase. Only .010 in. had to be removed when redressing was necessary.

Lehigh H (AISI D-2) is our standard high-carbon, high-chromium grade of air-hardening tool steel. It is a deep-hardening grade with high compressive strength. It has high wear-resistance, plenty of toughness, and minimum size change during heat-treatment — the characteristics you need most for maximum production.

TYPICAL ANALYSIS

Carbon 1.55 Chromium 11.50 Molybdenum 0.80
Manganese 0.40 Vanadium 0.90

The best way to appreciate the advantages of Lehigh H is to put it to work. A trial run in your shop can be arranged by your local Bethlehem tool steel distributor.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

You Can Remedy Fatigue-Failures

Chisels and other tools which are subjected to repeated stresses often fail suddenly. Because these tools are made from shock-resisting steel, the sudden failures can appear mysterious. However, close inspection of the failed parts often reveals that the failures were not sudden at all. They occurred because a crack progressed part way through the section, followed by sudden fracture of the remaining section.

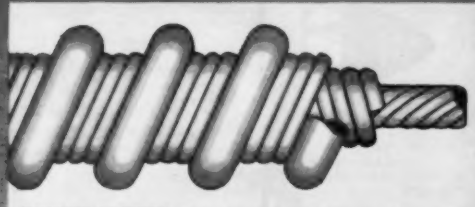
Fatigue-fractures have a characteristic, smooth-rubbed surface where the initial crack opened up, plus an inner crystalline zone revealed by the final sudden break. Often the smooth-rubbed surface shows parallel "oyster-shell" markings, and sometimes, evidence of rusting.

As a rule, fatigue-failures begin at a stress-concentration point, such as a notch, a poor fillet, tool mark, accidental nick, or deep stamping. The proper cure is to correct such design or mechanical faults promptly.

USE UPSET-FORGED DISCS FOR ALUMINUM EXTRUSIONS TOOLING

Bethlehem produces a full line of upset-forged discs for the manufacture of dies for aluminum extrusions. The discs are forged by expert hammer crews. They are finished in ring dies to insure good section. You can choose from two grades of tool steel—Cromo-WV, chrome-moly-tungsten-vanadium (H-12), and Cromo-High V, chrome-moly-high vanadium (H-13). Each grade has good resistance to erosion and heat-checking.

How NS solved another special wire problem



REMOTE CONTROL cable for jet aircraft is made of layers of high-tensile National-Standard wire wound around a stranded core. Heavy outer wire provides helix or worm-gear surface for meshing with hobbed wheels.

Photo courtesy Pan American Airlines

Special National-Standard wire helps fly new jet-liners

When the age of commercial jet transportation in the U.S. began last January, giant jet-liners inaugurated flights across the country at speeds over 600 mph. To control these new aircraft swiftly and easily requires control cables of the utmost reliability, efficiency and endurance.

NEW COMMERCIAL JET-LINERS, as well as many military aircraft, are flying now with a unique remote control cable system made of special high-tensile wire wound around a stranded core with a heavy outer wire of stainless steel wound to a pitch of 10 per inch. This outer wire acts as a helix to engage hobbed wheels within the various system control boxes.

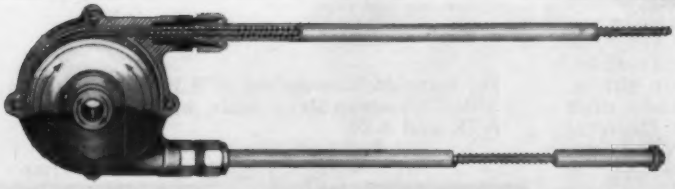
NATIONAL-STANDARD ENGINEERS worked closely with a control-cable system manufacturer to develop wire of just the proper alloy and rugged physical properties required to withstand extreme temperature and flight stress variations. National-Standard submitted wire samples to microstructural studies and physical tests to assist the customer in determining the conditions that would allow bending cable around pulleys without giving a permanent set to the cable. In addition, alloy steels with various coatings were tested to improve wear and galling resistance for various applications. The result was the development of a special stainless-steel wire that exceeded rigid specifications.

EXPERIENCED ENGINEERING HELP, of this kind, for jobs requiring high-quality wire to meet special or unique applications, is available to *you* from National-Standard. For any of the many thousands of applications where only special wire will solve the problem, let National-Standard engineers go to work for you. Write for additional information to National-Standard Company, Niles, Michigan.

Manufacturer of specialty wire and metal products

NATIONAL NS NATIONAL-STANDARD Company **STANDARD**

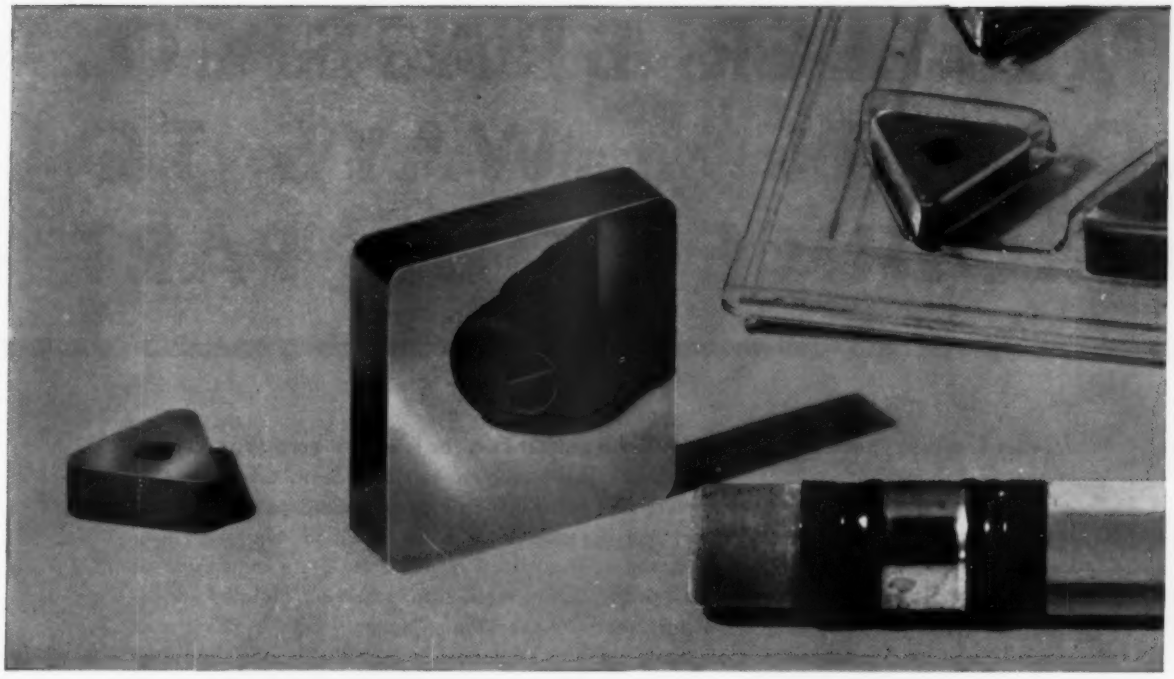
DIVISIONS: NATIONAL STANDARD, Niles, Mich.; tire wire, stainless, music spring and plated wires • **WORCESTER WIRE WORKS,** Worcester, Mass.; high and low carbon specialty wires • **WAGNER LITHO MACHINERY,** Secaucus, N. J.; metal decorating equipment • **ATHENIA STEEL,** Clifton, N. J.; flat, high-carbon spring steels • **REYNOLDS WIRE,** Dixon, Ill.; industrial wire cloth • **CROSS PERFORATED METALS,** Carbondale, Pa.; decorative, commercial, and industrial perforated metals.



FLEXIBLE CABLE engages accurately with specially hobbed wheels housed in control boxes. This combination requires special cable wire that will not take permanent set and will provide smooth, hard bearing surface for cable inside conduit.

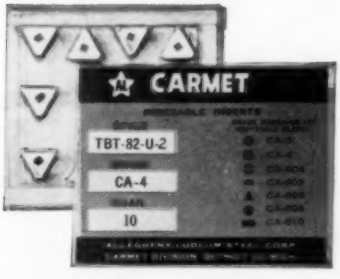
NATIONAL-STANDARD engineers made intense microstructural and tensile studies of sample wire to find exact physical properties of the alloy to meet strict aircraft control specifications.

For more information, turn to Reader Service card, circle No. 470



CARMET INDEXABLE INSERTS NOW LAPPED TO A MIRROR FINISH

to reduce chip wear and increase tool life



New Handy Plastic Slide Package

Individual pockets of heavy gauge, clear acetate now make it easy to check your Indexable Insert stock. Slides open for instant dispensing. Cardboard back carries Style, Grade and Quantity numbers plainly stamped. An index of grade markings of Indexable blanks for quick identification is included.

WRITE FOR FREE CATALOG C-16

"Carmet Cemented Carbides for Industry"

This 32-page first edition has prices and complete specifications on Carmet's full line of cemented carbide tipped tools, Indexable Inserts, blanks and holders. Speed and feed charts, grade comparisons, ordering information included.

ADDRESS DEPT. MM-16

Here's another Carmet "first" that cuts machining costs. Top surfaces of Carmet Indexable Inserts in all grades are now lapped with a super-fine grit diamond wheel to a bright mirror finish. And prices stay the same.

Chips just slip by on contact, so cratering and chip wear are reduced to a minimum. This low micro-inch finishing makes cutting edges stronger, too. Burrs and feather edges that contribute to early chipping are actually honed away. Cutting is cooler and more even. The tendency of some materials to stick is greatly reduced. Seating of the insert is highly improved to minimize the hazard of breakage when clamping.

Your Carmet distributor has Indexable Inserts in stock. He knows carbide tooling. Call him for any information you may want on grade selection, tool design or tool holder styles to make your current jobs more profitable. Or write Allegheny Ludlum Steel Corporation, Carmet Division, Detroit 20, Michigan.

WSW-7401

CARMET

CEMENTED CARBIDE DIVISION OF
ALLEGHENY LUDLUM STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 492

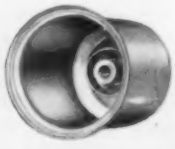
MUELLER BRASS CO. OFFERS 7 WAYS TO PRODUCE YOUR PART

Mueller Brass Co., because of its diversified manufacturing facilities that encompass a wide range of fabricating methods, is in the unique position of being able to offer you, the purchaser, an intelligent, unbiased analysis and recommendation of the best, most economical method by which your particular part can be produced. As the result of over 40 years' experience, the "Methods Analysis Department" has at its command complete knowledge of the advantages and limitations of each production process. After receiving detailed knowledge concerning the end use of the part, material specified, conditions under which it must operate and other pertinent factors, these analysis engineers make their recommendations. Every detail is considered. In many cases, methods analysis engineers recommend a simple design change that makes practical a much more economical method of production. This technical service, offered only by Mueller Brass Co., is given to each individual inquiry and is your assurance that you will get the best product at the best price . . . made the one best way . . . by Mueller Brass Co.

Send today for free technical literature on any one or all of the seven fabricating methods.

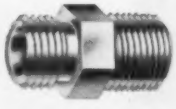
FORGINGS

Production equipment is available to produce press, hammer or cored forgings of any practical shape in sizes ranging from a few ounces to 150 lbs. in brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.



COLD-PREST® IMPACT EXTRUSIONS

Mueller Brass Co. has complete machinery for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Extrusions up to 28" in length are possible, depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with uniform or tapered wall sections.



SCREW MACHINE PRODUCTS

Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and non-ferrous custom parts. We can produce an infinite variety of shapes and sizes from ⅛" to 3¼" in wide range of free cutting and specialized alloys. Complete facilities for all secondary and finishing operations, as well.

POWDER METAL PARTS

Mueller Brass Co. can supply precision Sinteel® powder metal parts in wide range of sizes and metals at high production rate. Parts available from iron, brass and copper alloys. Parts may be ordered with such characteristics as self-lubrication, controlled porosity and good electrical and magnetic properties.

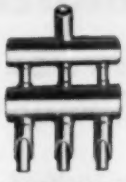
MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

MUELLER BRASS CO.

...and our methods analysis service helps you determine which is the best ...and most economical method

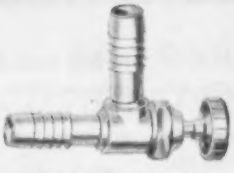
SAND CASTINGS

We specialize in the production of pressure-tight red brass castings. We utilize both metal match plate and wood patterns. Facilities include tool room and pattern shop, electric melting furnaces, high capacity core room and both bench and floor molding equipment to handle wide range of sizes.



FORMED COPPER TUBE

Mueller Brass Co. has modern facilities for forming seamless copper tube into a multitude of shapes. Forming methods used include bending, spinning, expanding or swedging, upsetting, flaring, flattening, beading and grooving, drilling and piercing, machining and joining. Formed copper tube coils are also available as single, double, spiral and serpentine shapes.



PLASTIC INJECTION MOLDING

Injection molding of plastic parts is still another process offered by the Mueller Brass Co. Parts are molded from such plastics as—nylon, polyethylenes, polyvinyl chloride, styrenes, linear acetal, chlorinated polyether, polycarbonates or polypropylene, dependent on part application.

MAN FROM MUELLER BRASS CO.

Since only Mueller Brass Co. can produce your part by all the methods, only the Man From Mueller Brass Co. can give sound advice on the one best method of production. Over 40 years of research, engineering, manufacturing and marketing experience stands behind him. When you are specifying and purchasing fabricated metal parts, call in the MAN FROM MUELLER BRASS CO.

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PORT HURON 21, MICHIGAN

For more information, turn to Reader Service card, circle No. 475

LAUNCHING AT SEA. Unarmed as it roars skyward, the Terrier guided missile is armed in the air by action of "heavy metal" counterweights. Most "heavy metals" contain 6-7% Nickel. *Official U. S. Navy photograph.*

How the Terrier "unmuzzles" itself

The Navy's Terrier guided missile is "muzzled" as it streaks from its launching vessel into the sky. A safety mechanism keeps the missile from exploding prematurely even under severe shock conditions.

Cocking action is automatic. At a minimum safe distance from the deck, the force of acceleration depresses spring-loaded weights. Their movement cocks the missile.

The weights are made of Fansteel 77* metal, one of a group of high-density tungsten alloys containing Nickel and copper which are described by the simple but expressive term, heavy metal.

Heavy metal packs a lot of weight into a little space. It weighs half again as much as lead, yet is stronger than structural steel.

Tungsten is heavy by itself, of course, but is relatively difficult to shape. By combining it with Nickel by powder metallurgy, the Nickel and tungsten powders can be formed into shapes that require very little further finishing.

Many other uses. In addition to the partnership of *weight* and *workability*, heavy metal offers another desirable combination: *good corrosion resistance* and *moderate cost*. This foursome is responsible for bringing heavy metal more and more jobs daily — jobs ranging from electrical and electronic parts to radiation shielding and vibration damping.

Do you have a metal problem weighing you down? Perhaps one that involves corrosion . . . high or low temperatures . . . stress . . . fatigue . . . or other troublesome service conditions? Talk it over with us. Nickel alloys offer many unusual properties, and can very likely prove useful in lightening your burden.

*Registered trademark of Fansteel Metallurgical Corp.

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

"WEIRKOTE® WON'T PEEL OR FLAKE—AND CAN END THE NEED FOR FURTHER CORROSION PROTECTION AFTER FABRICATION."

Q. A zinc-coated steel sheet that won't peel or flake, even under the severest fabricating stresses?

A. Precisely. Weirkote's made by a continuous process. The zinc is so integrated with the steel that even the toughest "torture" tests of fabrication leave that bonded coating intact. You can work Weirkote to the very limits of the steel itself!

Q. Our products are pretty intricate—take lots of flexing, crimping and so on. What about those hard-to-reach places?

A. Weirkote's zinc coating is so uniform—protects even the most complicated parts.

Q. So with Weirkote you bypass the need for further corrosion protection?

A. You get the picture! Think of the time, labor, space—the costly capital outlay—you save. Better steel products at far lower costs—that's Weirkote for you!

Send for free booklet that details the time-and-cost-saving advantages of skin-tight zinc-coated Weirkote. Just write Weirton Steel Company, Dept. E-2, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

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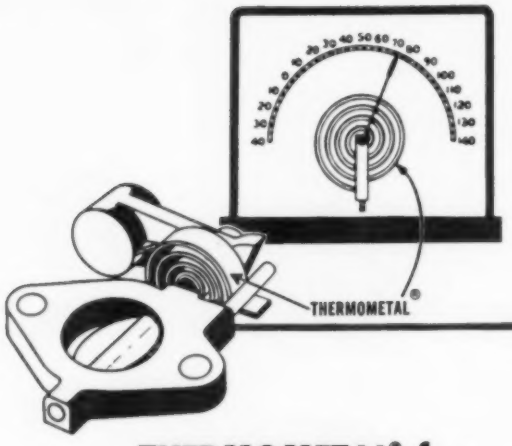
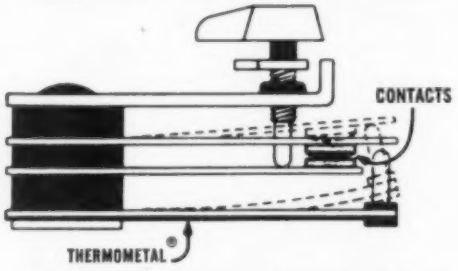


THERMOMETAL® for dependable temperature, electrical current and voltage control applications



Leading manufacturers depend upon the outstanding performance of Thermometal in electrical appliances, thermal cutouts, heating controls and many other applications involving the indication and accurate control of temperatures, electrical currents, voltages, etc. Thermometal is supplied in strip form, rolled and slit to close tolerances and tempered to specification. Thermometal elements and sub-assemblies are also supplied to specifications, with or without contacts attached. Send for literature.

H. A. WILSON DIVISION • U.S. HIGHWAY 22
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look to Amersil for all high purity fused quartz requirements.

Amersil manufactures and fabricates high purity fused quartz for ultraviolet transmission applications, laboratory ware and production equipment. These products include standard apparatus, plain tubing in many intricate fabrications, crucibles, trays, cylindrical containers and piping in a full range of sizes up to 25" in diameter. Ingots and plates are available in general commercial quality as well as in special optical grades. Amersil engineers are also prepared to assist in developing fused quartz and silica equipment for special requirements. Send for bulletin.

AMERSIL QUARTZ DIVISION • 685 RAMSEY AVENUE
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AMERSIL QUARTZ DIVISION

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a simplified mirror-bright silver plating process

Here is the most efficient, simple procedure to protect electrical electronic and lamp components with a mirror-bright silver finish—through a complete range from flash to heavy deposit. The procedure is easy, economical and non-critical—with little or no polishing required. Silva-Brite is a clear, water-white solution, enabling the operator to observe work as it is being plated. Uniformly good results are attained with current densities ranging from 10 to 40 amperes per square foot. Normal room temperature operation minimizes fumes and tendency toward bath decomposition. Send for descriptive data together with detailed plating procedures.

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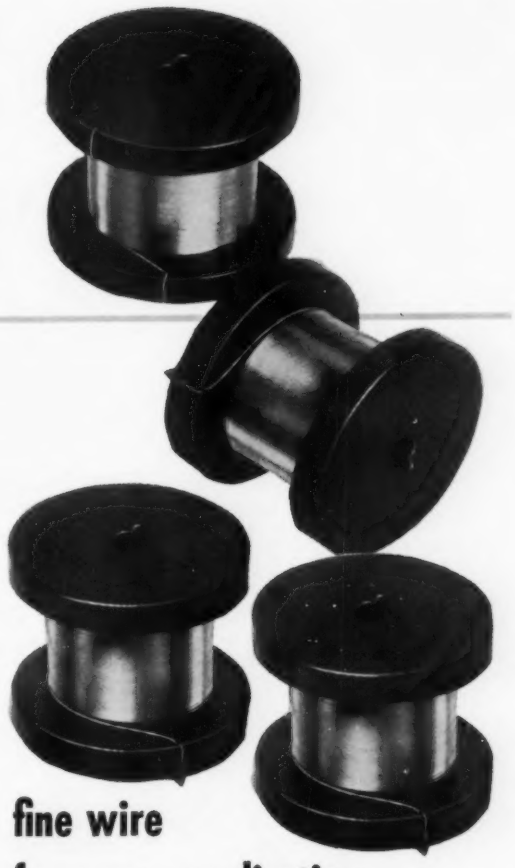

fine wire for every application

Here, you will find a thoroughly dependable source for fine wire of ductile and non-ductile materials for every application. Special processes have been developed for bare drawing wire as fine as .0004". Where smaller fine wire is required, the Wollaston Process for ductile metals and the Taylor and Extrusion methods for non-ductile materials are employed. All standard fine wire requirements are stocked for prompt delivery. Full facilities are available for the production of fine wires made to your own specifications.

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ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:

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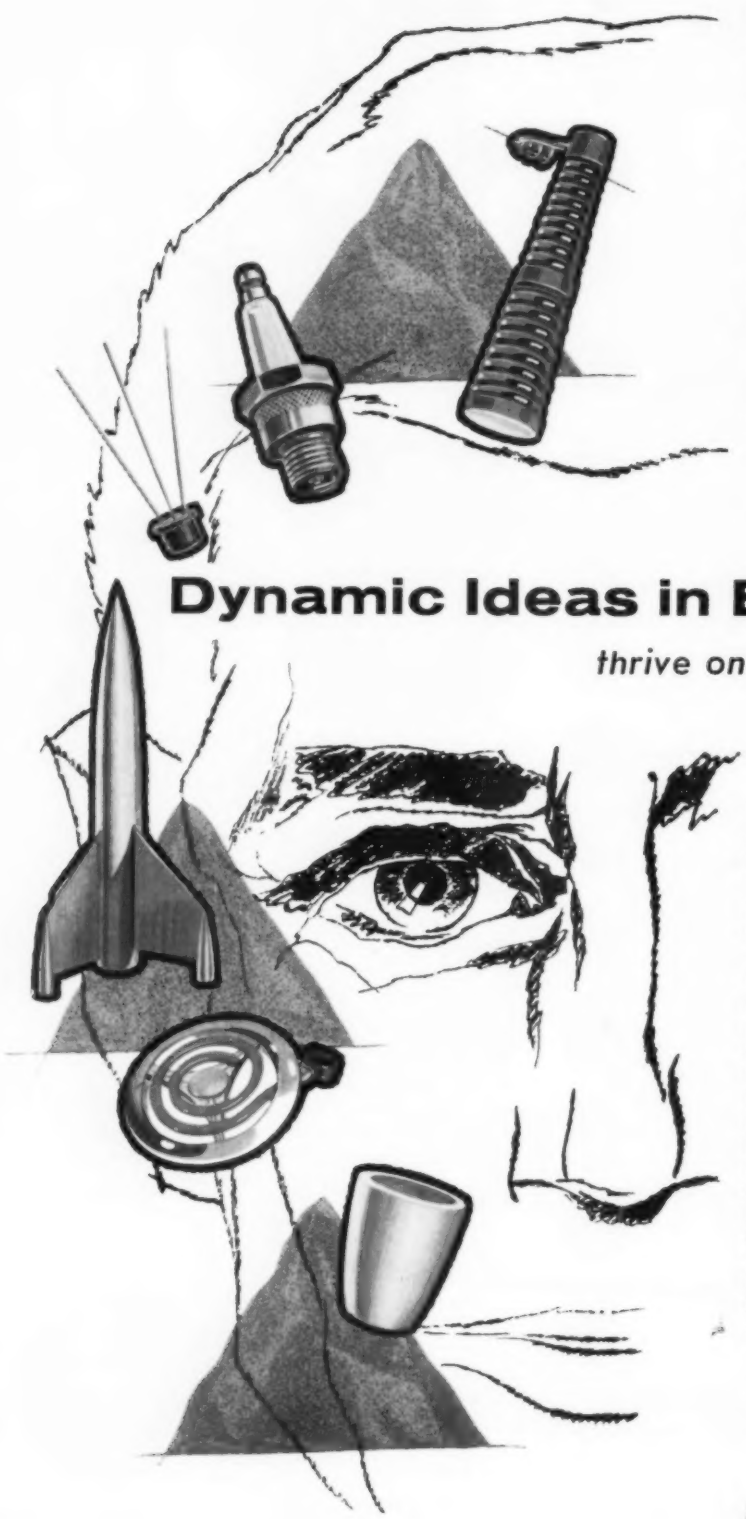

Dynamic Ideas in Engineering . . .

thrive on Norton ceramic materials

Here are the "basic ingredients" in some of today's most advanced design concepts . . . Norton Ceramic Materials. Exceptionally versatile, these exciting materials are meeting operating requirements of products and processes across industry.

Norton Ceramic Materials offer design engineers a wide range of outstanding physical, chemical, thermal, and electrical properties. What's more, they provide interesting *combinations* of these properties. For example: CRYSTOLON* silicon carbide provides high thermal conductivity as well as exceptional thermal strength; ALUNDUM* aluminum oxide has excellent chemical stability in addition to good abrasion resistance; MAGNORITE* magnesium oxide offers high purity, thermal and electrical resistance; fused zirconium oxide is today's highest melting point material available in tonnage quantities and it's immune to both reducing and oxidizing atmospheres. And each product has *many* other invaluable properties.

Think of Norton Ceramic Compositions as essential components in equipment for metal and chemical processing, electrical, electronic, ceramic and nuclear applications . . . as "the answer" to literally hundreds of design problems. They're manufactured to meet highly exacting standards of purity, density, shape, size and wear resistance . . . available in granular and in fabricated form to meet *your* requirements efficiently and economically. For complete details, write for "Norton REFRACTORY GRAIN". NORTON COMPANY, Refractories Division, 343 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

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REFRACTORIES
Engineered . . . Rx . . . Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEHR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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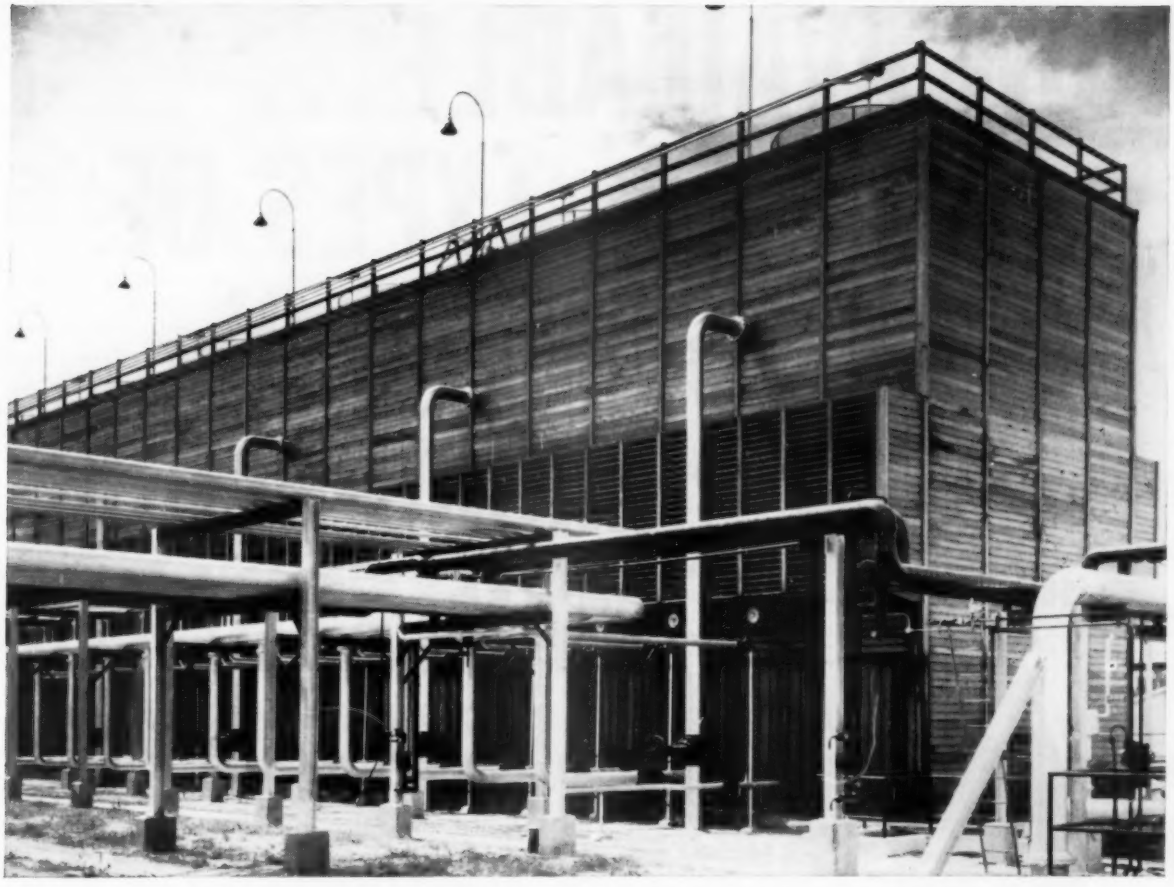


CHROMATE COMPOUNDS STOP CORROSION *before it starts!*

Long before the first drop of water contacts metal in any large recirculating water system, steps should be taken to prevent corrosion.

Early in the design stage, plan on adding a chromate inhibiting compound to recirculating water—from the moment operation starts. That way, clean metal stays clean. Chromate inhibiting compounds will also arrest corrosion in older systems that have been operating without protection, even where rust and scale make it more difficult for inhibitors to reach and protect the metal.

Chromates work two ways: they make waters non-corrosive while making metal surfaces corrosion-resistant. Chromate inhibiting compounds are easy and inexpensive to use. Since conditions and equipment vary, a variety of compounds are available to meet individual requirements.

For the names of manufacturers of corrosion inhibiting compounds containing Mutual Chromium Chemicals, or information on Mutual Chromium Chemicals, mail the coupon below.

Mutual® Chromium Chemicals

Sodium Bichromate
Sodium Chromate
Chromic Acid
Potassium Bichromate
Potassium Chromate
Ammonium Bichromate
Korean (one-bath chrome tan)

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

Allied Chemical

MUTUAL Chromium Chemicals are available through dealers and SOLVAY branch offices located in major centers from coast to coast.

MUTUAL CHROMIUM CHEMICALS
SOLVAY PROCESS DIVISION
Allied Chemical Corporation
61 Broadway, New York 6, N. Y.

Please send:

- ☐ List of manufacturers of corrosion inhibiting compounds.
- ☐ Booklet "Mutual Chromium Chemicals."

Name_____ Position_____

Company_____

Street_____

City_____ Zone____ State_____ 22-4

For more information, turn to Reader Service card, circle No. 425

NOW AVAILABLE...

TYPES OF AMERIPOL MICRO-BLACK MASTERBATCH

TYPE 4650

A high dispersion carbon black masterbatch consisting of HAF black in a rosin acid emulsified cold polymer. Composition: Type 1500 Ameripol, 100 parts; HAF black, 55 parts; heavy processing oil, 10 parts. For tires, premium quality tread rubber, mechanical goods, extruded goods.

TYPE 4651

A high dispersion carbon black masterbatch consisting of HAF black in a rosin acid emulsified cold polymer. Composition: Type 1500 Ameripol, 100 parts; HAF black, 62.5 parts; heavy processing oil, 12 parts. For tires, premium quality tread rubber, mechanical goods, extruded goods.

TYPE 4652

A high dispersion carbon black masterbatch with a high loading of medium thermal black in a rosin acid emulsified cold SBR copolymer. Composition: Type 1501 copolymer, 100 parts; medium thermal carbon black, 150 parts. For mechanical goods, floor matting.

TYPE 4654

A high dispersion carbon black masterbatch of ISAF black in a rosin acid emulsified cold SBR copolymer. Composition: Type 1500 copolymer, 100 parts; ISAF black, 52 parts; heavy processing oil, 10 parts. For tires, premium quality tread rubber.

TYPE 4655

A high dispersion carbon black masterbatch of HAF black in a rosin acid emulsified SBR copolymer. Composition: Type 1500 copolymer, 100 parts; HAF black, 52 parts; heavy processing oil, 10 parts. For tires, premium quality tread rubber, mechanical goods, extruded goods.

TYPE 4750

A high dispersion carbon black masterbatch of HAF black in a highly aromatic oil extended, mixed acid, SBR copolymer. Composition: Type 1712 oil extended copolymer, 137.5 parts; HAF black, 75 parts. For tires, medium quality tread rubber.

TYPE 4751

A high dispersion carbon black masterbatch of FEF black in a naphthenic oil extended, all fatty acid, SBR copolymer. Composition: Type 4700 oil extended copolymer, 150 parts; FEF black, 100 parts. For low cost tread rubber, automotive extrusions, mechanical goods, floor matting.

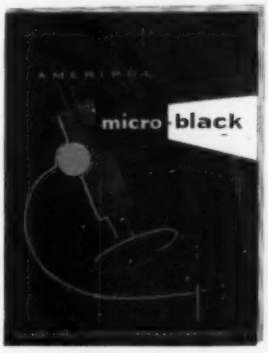
Now you can select the right black masterbatches for your particular products from *seven* high-dispersion types offered by Goodrich-Gulf.

These Ameripol Micro-Black masterbatches will help you improve your process control, mix rubber recipes easier and faster, reduce handling and compounding costs, and gain superior dispersion over conventional dry mixes. Here's why.

High liquid-shear agitation in the Goodrich-Gulf process assures thorough dispersal of carbon black at the latex stage, just before coagulation, in the production of Micro-Black masterbatches. You get better batch uniformity. Greater abrasion resistance in your finished products.

See how you can cut costs with Ameripol Micro-Black. You eliminate a weighing and mixing operation, and a messy clean-up problem, because carbon black is already integral with the compound. Warehousing is simplified because you eliminate one raw material. Handling is easier, too, because Micro-Black is shipped bareback. It does not cold flow.

New data book—For complete information on all seven of these black masterbatches, write for new illustrated Micro-Black data book.



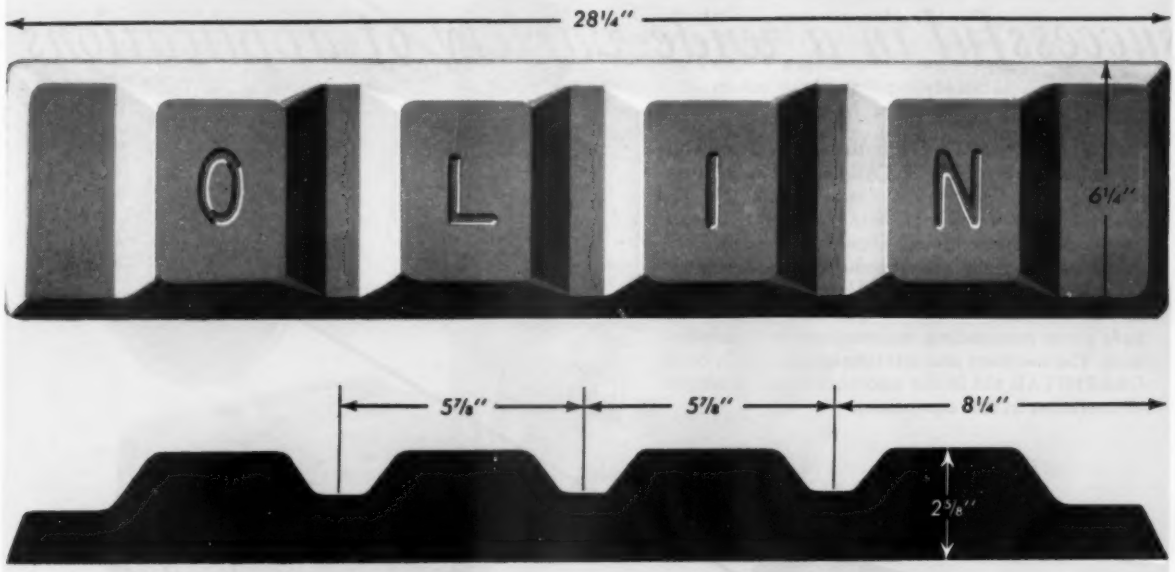
Goodrich-Gulf Chemicals, Inc.

3121 Euclid Avenue, Cleveland 15, Ohio

	Type 4650	Type 4651	Type 4652	Type 4654	Type 4655	Type 4750	Type 4751
Chemical Properties							
Volatile matter, %	0.11	0.12	0.05	0.12	0.12	0.15	0.09
Ash, %	0.28	0.32	0.13	0.20	0.14	0.31	0.19
Rosin acid, %	3.83	3.74		3.84	3.81		
Rosin soap, %	0.01	0.01	0.00	0.01	0.00	0.04	
Organic acid, %			2.48				
Mixed acid, %						2.77	
Fatty acid							2.16
Physical Properties (Cure 50′ @ 292° F.)							
Tensile, psi.	3315	3389	1660	3950	3370	3340	2265
Elongation, %	547	474	470	650	655	660	440
Modulus, 300%, psi.	1742	2243	1200	1400	1295	1380	1650
Hardness, Shore A	64	68	64	65	60		66
Compound viscosity, ML4 @ 212° F.	60	69	82	54	52	72	79
Test Recipe							
Ameripol	150.0	156.0	250.0	147.5	147.5	154.5	166.5
Zinc oxide	5.0	5.0	5.0	5.0	5.0	1.5	5.0
Sulfur	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Stearic acid	1.5	1.5	1.5	1.5	1.5	—	—
Benzothiazyldisulfide	2.0	2.0	2.0	2.0	2.0	1.0	1.5
	160.5	166.5	260.5	158.0	158.0	159.0	175.0

NOTE: Above data based on the test recipes indicated. They are given for information only, as we cannot accept responsibility for operations not under our direct control.

YOU'LL FIND GOLD
IN THIS NEW 25 POUND OLIN ALUMINUM INGOT!



Now, a 25 pound ingot from Olin Aluminum. Consider its advantages for you!

Smaller size. Easier to store, easier to gauge metal supply for closer control.

Lighter weight. 25 lbs. vs. 30 lbs. Greatly increases handling efficiency.

Deeper notches. Easier to break. Saves time, eases work load.

More sections. 3 notches, 4 sections vs. 2 notches, 3 sections. Reduces waste.

Same price per pound as 30 lb. ingot. Olin Aluminum is the only prime supplier producing a 25 pound ingot, and at no additional cost.

America's new major aluminum producer, Olin Aluminum, is also the newest source of profitable ideas for foundrymen. Take advantage of it. Contact your nearby Olin Aluminum Sales Office or Authorized Distributor of casting alloys. Ask for our pig and ingot technical data bulletin. Metals Division – Olin Mathieson Chemical Corporation, 400 Park Avenue, New York 22, New York.

OLIN ALUMINUM

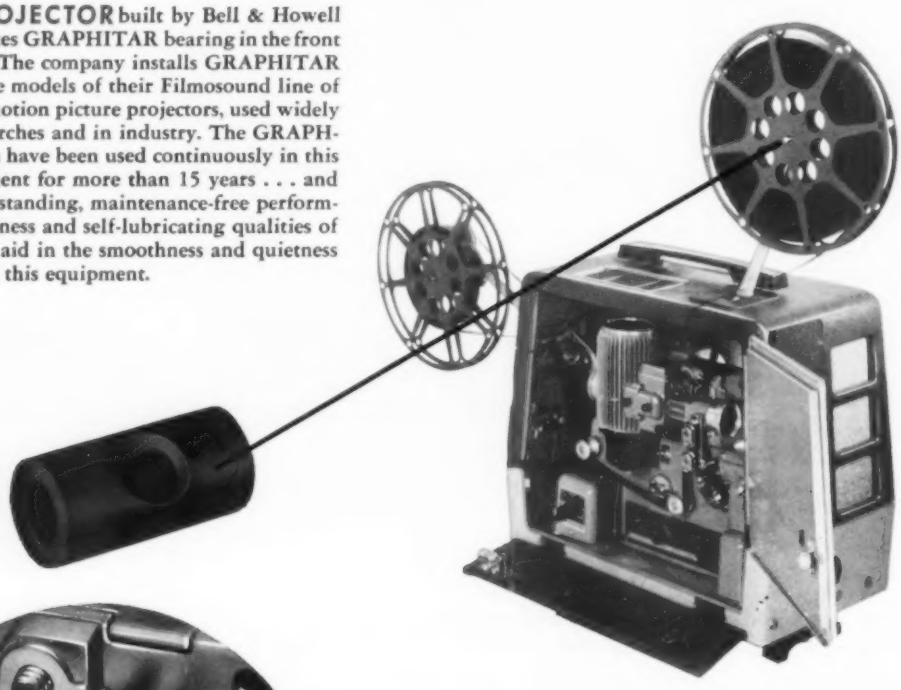
Symbol of New Standards of Quality and Service in the Aluminum Industry

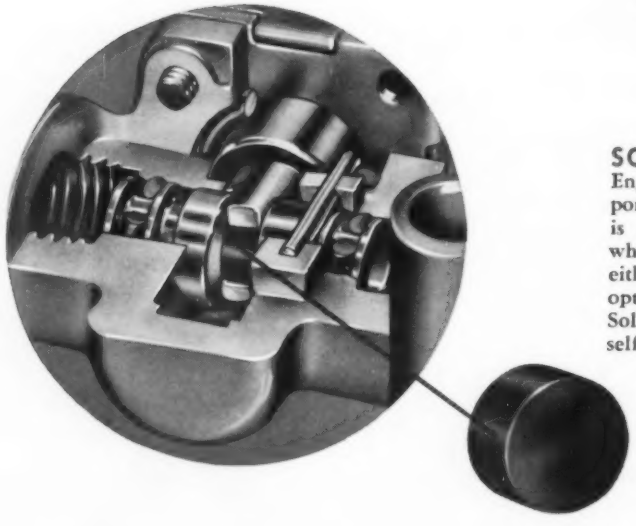
For more information, turn to Reader Service card, circle No. 459

this is GRAPHITAR®
(CARBON-GRAPHITE)

successful in a wide variety of applications

MOVIE PROJECTOR built by Bell & Howell Company utilizes GRAPHITAR bearing in the front reel assembly. The company installs GRAPHITAR bearings in five models of their Filmosound line of 16mm sound motion picture projectors, used widely in schools, churches and in industry. The GRAPHITAR bearings have been used continuously in this line of equipment for more than 15 years . . . and have given outstanding, maintenance-free performance. The hardness and self-lubricating qualities of GRAPHITAR aid in the smoothness and quietness of operation in this equipment.





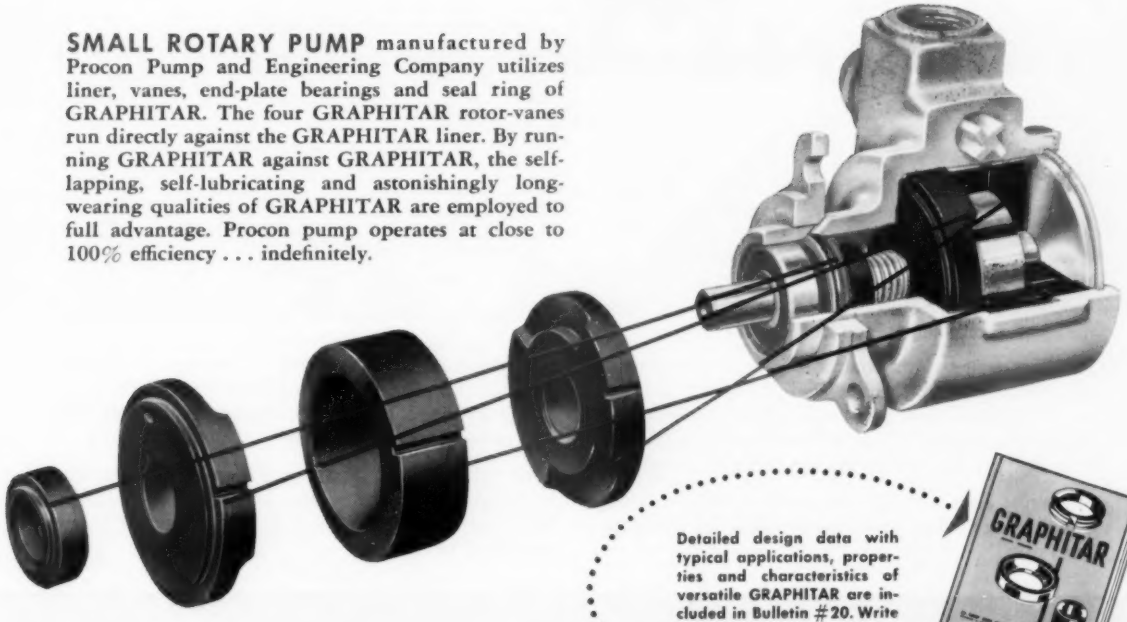
SOLENOID VALVES manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

HERMETICALLY SEALED MOTOR-PUMPS have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

SMALL ROTARY PUMP manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.

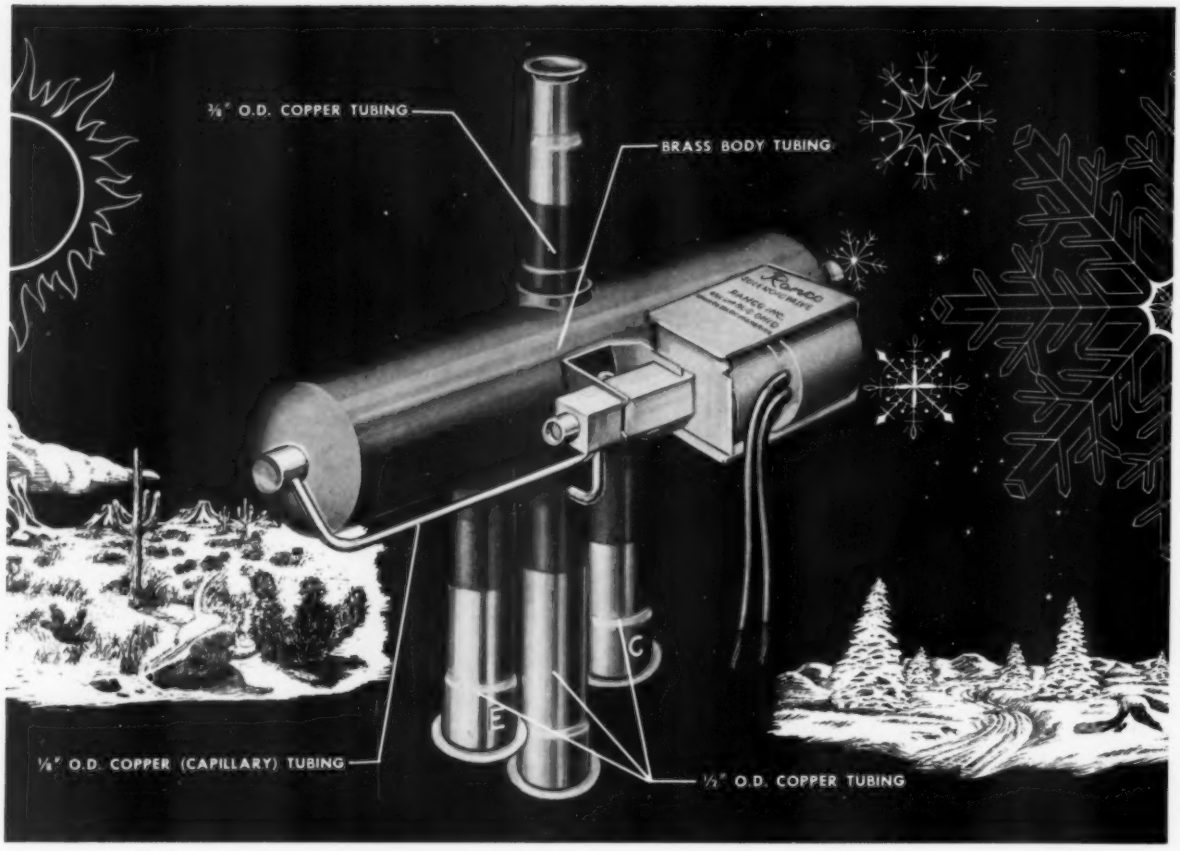


Detailed design data with typical applications, properties and characteristics of versatile GRAPHITAR are included in Bulletin #20. Write for your free copy.

R-265-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN



"Everybody talks about the weather..."

WOLVERINE TUBE HELPS RANCO ACHIEVE YEAR 'ROUND AIR CONDITIONING COMFORT!

Blow hot . . . blow cold . . . whatever the weather, the reversing valves manufactured by Ranco Incorporated, Columbus, Ohio, act as the nerve center for providing the right type of climate to meet either condition.

Ranco reversing valves control heat pump operation in air conditioning units—both window and central types. In cold weather, these units extract heat from outside air and circulate it indoors—in summer the cycle is reversed with heat gathered from indoors released outside.

Wolverine Tube manufactures much of the copper and brass tubing used by Ranco in manufacturing its reversing valves.

Among this tubing is Wolverine Capilator®—the tiny capillary tubing for precision metering of liquids and gases. The valve body proper is formed from Wolverine brass tubing and the ports leading to the compressor and inside and outside exchangers are manufactured from Wolverine copper tube.

Wolverine Tube is proud that its tubular products are so widely used by Ranco and other leading manufacturers throughout American industry . . . believes that this is the result of its Tubemanship program from which comes tubing conceived in research and sound engineering and backed by years of experience.

If your company uses copper, copper alloy or aluminum tubing get the Wolverine story before you order again. Just write for your free copy of the "Measure of Tubemanship." Do it today.

CALUMET & HECLA, INC.:
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION
In Canada:
CALUMET & HECLA OF CANADA LIMITED
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO. LTD.
UNIFIN TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17250 Southfield Road
Allen Park, Michigan
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT. 13 E. 40TH ST., NEW YORK 16, N.Y.

For more information, turn to Reader Service card, circle No. 542

For more information, circle No. 496 ➤

Pen making is a precision business, and standards are high. That's why top pen manufacturers show a decided preference for Forticel—the Celanese propionate plastic.

Forticel is the sure starting point for good pen engineering. This brilliant material responds as readily to machining, slotting and threading as it does to fast-cycle injection molding.

Forticel, favorite for pens, also meets the specifications for a host of critical consumer and industrial applications—from pens and telephones to transistor radio housings and automotive parts. Here is the plastic that delivers both eye appeal and function. Use coupon for more information.

Celanese® Forticel®

Forticel...a Celanese plastic

Canadian Affiliate: Canadian Chemical Co. Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N. Y. 16

TYPICAL PHYSICAL PROPERTIES OF FORTICEL

Flow temperature: (°C.) (A.S.T.M.)	D569-48	145—183
Specific gravity	D176-42T	1.18—1.24
Tensile properties:		
Break (p.s.i.)	D638-52T	1900—5900
Elongation (%)	D638-52T	48—63
Flexural properties:		
Flexural strength (p.s.i. at break)	D790-49T	3300—10700
Rockwell hardness: (R scale)	D785-51	−15 to 106
Izod impact: (ft. lb./in. notch)	D256-43T	1.2—11.0
Heat distortion: (°C.)	D648-45T	51—70
Water absorption:		
% sol. lost	D570-42	0.00—0.08
% moisture gain	D570-42	1.5—1.8
% water absorption	D570-42	1.6—2.0

Celanese Corporation of America, Plastics Division
Dept 102-D, 744 Broad Street, Newark 2, N. J.

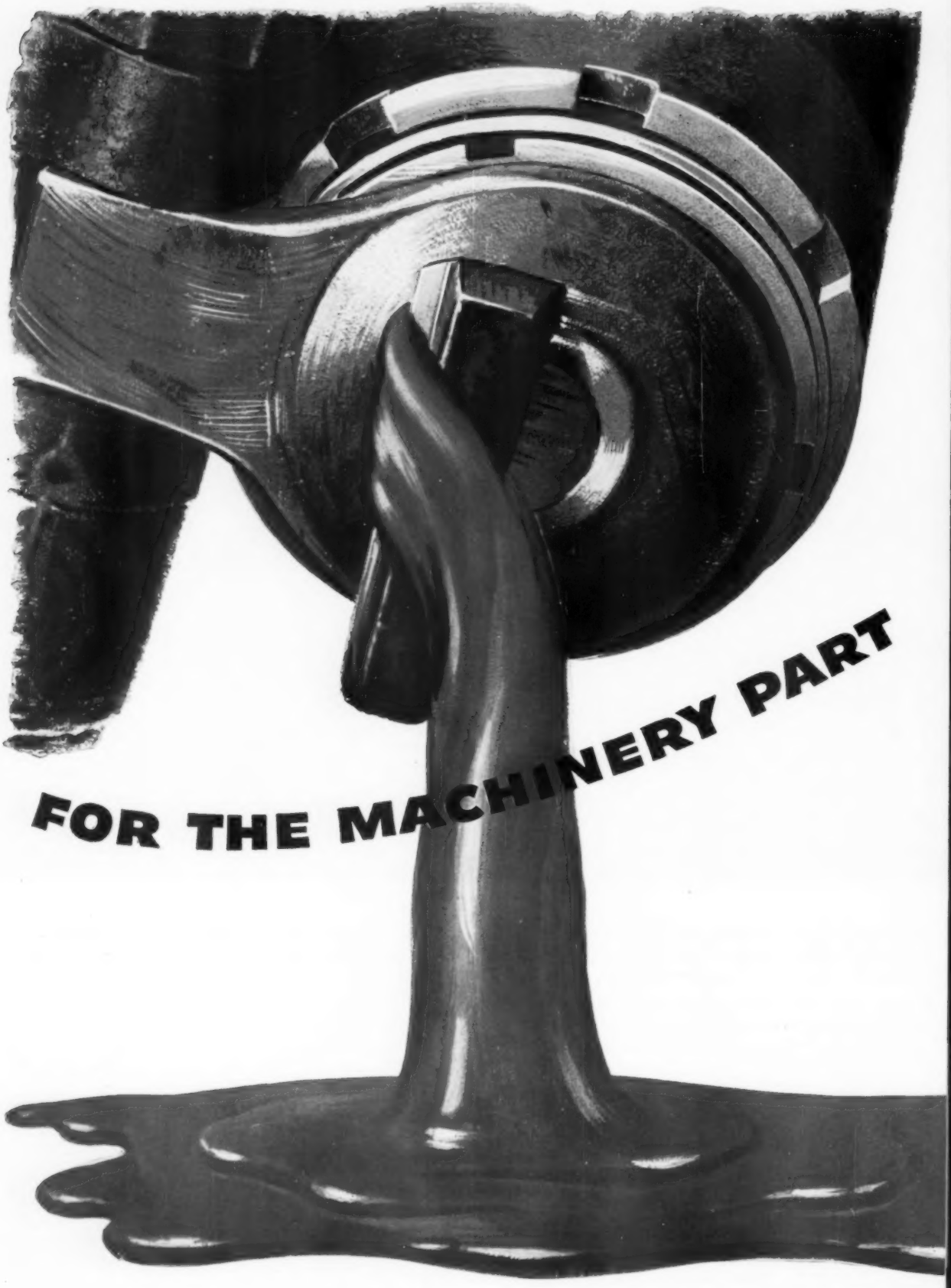
Please send me New Product Bulletin A2A on Forticel Plastic.

Name _____ Title _____

Company _____

Address _____

City _____ State _____


FOR THE MACHINERY PART

THAT TAKES THE BEATING

A cut-off knife made of HAYNES STELLITE alloy No. 19 slices through molten glass at 2200 deg. F. Despite the intense heat of the glass being molded into tumblers, and the severe erosive action of the glass on metal, the cut-off knife maintains a 0.015-in. clearance between itself and the mold ring . . . *far longer than any other material ever used.*

HAYNES Alloys *will do the job!*

Are you looking for a tough metal part to improve your machinery? It will pay you to look into HAYNES alloys. There are more than 15 from which to choose, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. Parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist many conditions of wear, heat, or corrosion.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

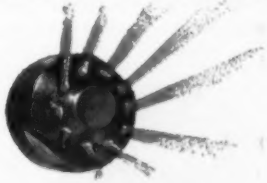
Kokomo, Indiana

UNION CARBIDE

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS

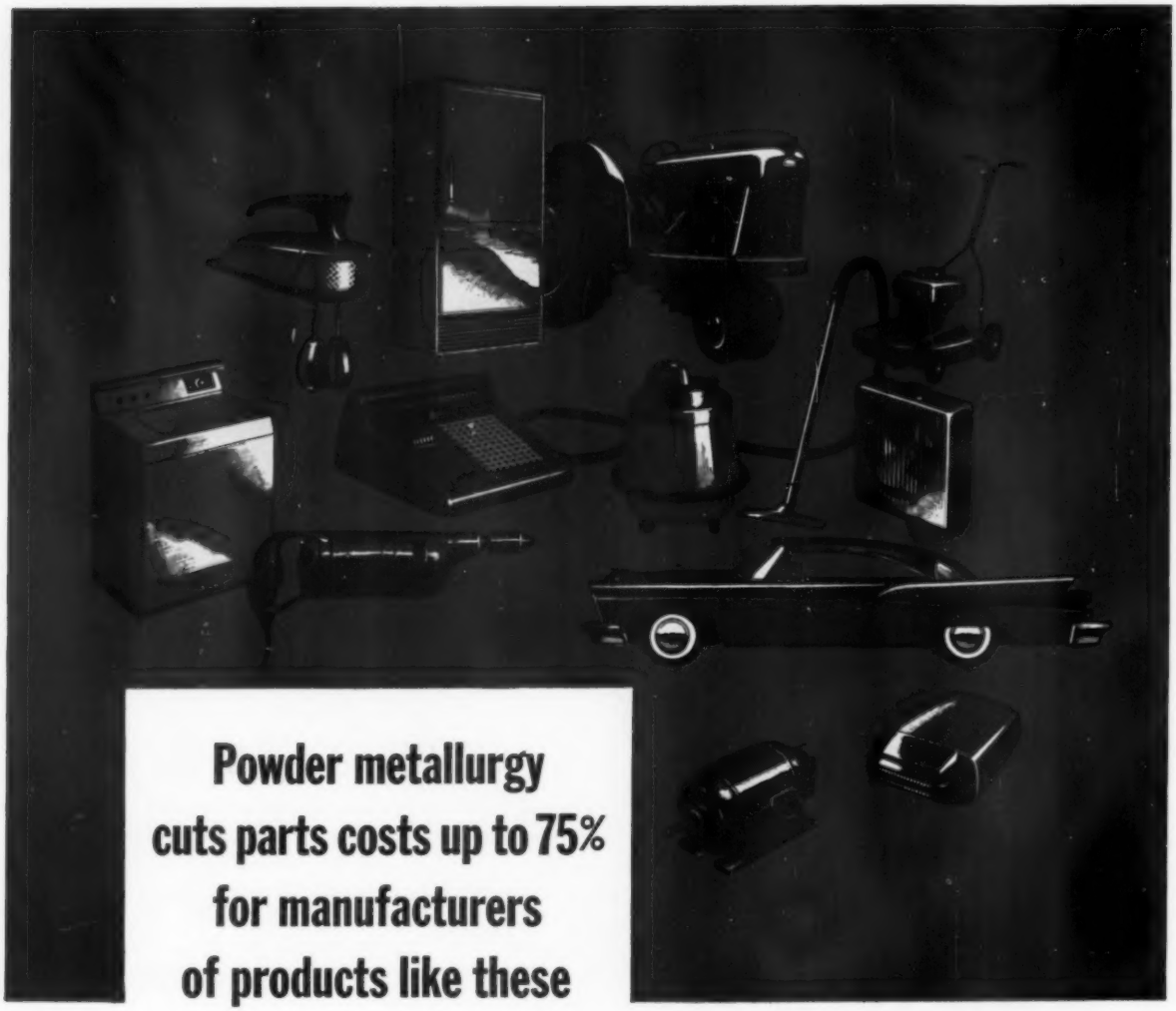
Tough, long-lasting metal-cutting saws over 20 inches in diameter, made of HAYNES STELLITE alloy sheet, slice the tops off copper ingots.



Steam atomizer fuel burner nozzles of HASTELLOY alloy C resist corrosive agents and erosion for months, retaining essential contours.

High-temperature strength and corrosion resistance of diesel combustion chambers made of HASTELLOY alloy C make them "good for life of the engines."

For more information, turn to Reader Service card, circle No. 477

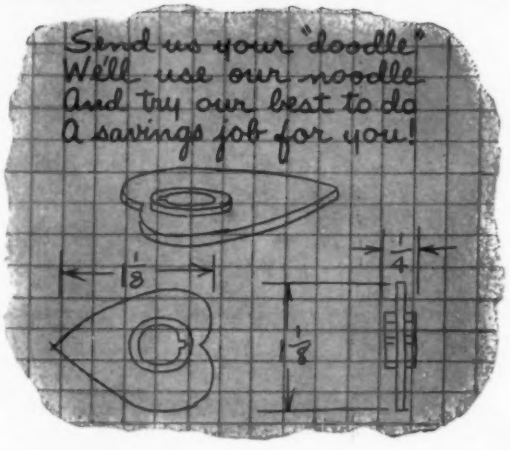


Powder metallurgy cuts parts costs up to 75% for manufacturers of products like these

Why not find out now if powder metallurgy holds the answer to your high parts costs?

Send Glidden a sketch of any part, plus the quantity desired. Glidden, with the help of qualified parts fabricators in your area, will determine, first, whether the part can be made with metal powder. If it can, you will receive cost quotations that may show really worthwhile savings—similar to savings realized by an increasing number of manufacturers who have found that metal powder parts can be mass-produced faster, better, more economically.

As a leading supplier of metal powders, Glidden works closely with parts producers. In this way, several staffs of experienced technicians may be at your disposal—to provide complete technical service and suggest possible design changes that may bring even lower parts costs.



QUALITY Glidden PRODUCTS

RESISTOX METAL POWDERS

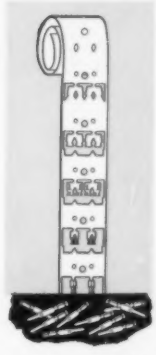
The Glidden Company
Chemicals—Pigments—Metals Division
Hammond, Indiana

COPPER POWDER • LEAD POWDER • TIN POWDER • BRASS POWDER • ALLOY POWDER • FILTER POWDER
CUPRIC OXIDE • CUPROUS SULFIDE • CUBOND COPPER BRAZING PASTE • COPPER PIGMENT

For more information, turn to Reader Service card, circle No. 397

Want to eliminate parts plating?

Use Sylvania Plated Metal Strip



AUTOMATION-WISE, plating metal parts after stamping can be waste motion and interrupt flow. Designers have found they can often eliminate the plating step by starting with plated metal strip. Production and assembly of parts can then be incorporated into continuously automatic production lines, smoothly and economically. With its unique plating process, Sylvania can plate metal strip on a single side or on both sides; can plate one side heavy, the other side thin; and can plate each side with a different material.

We've already plated base metals of steel, stainless, brass, bronze, copper, nickel, and aluminum with nickel, tin, silver, and copper. Strip up to .040″ thick and 10″ wide can be plated up to .005″ thick per side. Some unusual combinations are in development to meet special needs—maybe you have a custom plating requirement too.

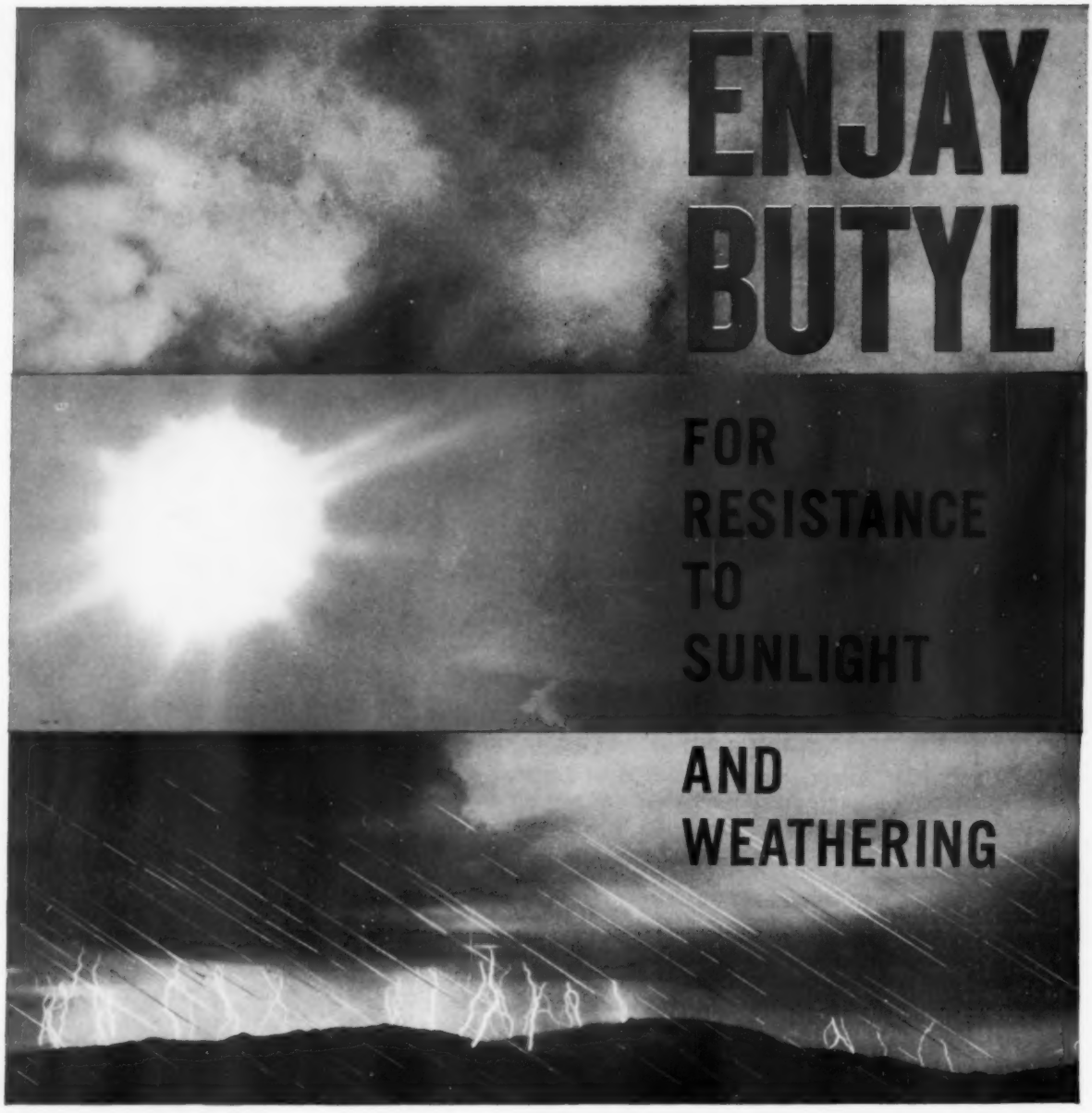
Let us know your needs or write for our Plated Strip Technical Bulletin. Write to:

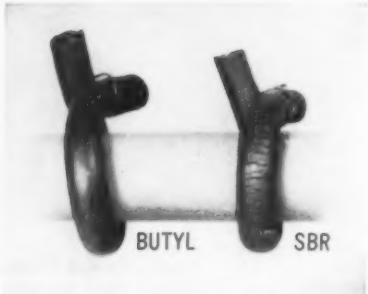
SYLVANIA ELECTRIC PRODUCTS INC.
Parts Division, Warren, Pa.

SYLVANIA PARTS DIVISION

Custom Molded Plastics
Custom Metal Stampings
Custom Welded Parts
Custom Assemblies
Alloy, Clad, Plated Wire
Plated Metal Strip
Electronic Components
Fluorescent Components

For more information, turn to Reader Service card, circle No. 521





Butyl's high resistance to ozone is graphically demonstrated when compared with SBR or natural rubber

Enjay Butyl rubber has demonstrated for many years its outstanding ability to resist deterioration caused by sunlight and weathering. This inherent resistance of Butyl to ultra-violet light, ozone, oxidation, moisture and mildew, has made possible many new and colorful products. Butyl has also increased the life of other products such as weatherstrips, protective coating, garden hose, wading pools and many automotive parts.

Butyl *also* offers...outstanding resistance to chemicals, abrasion, tear and flexing . . . superior damping qualities . . . unmatched electrical properties and impermeability to gases and moisture.

For more information call or write the Enjay Company.

ENJAY® BUTYL

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N. Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

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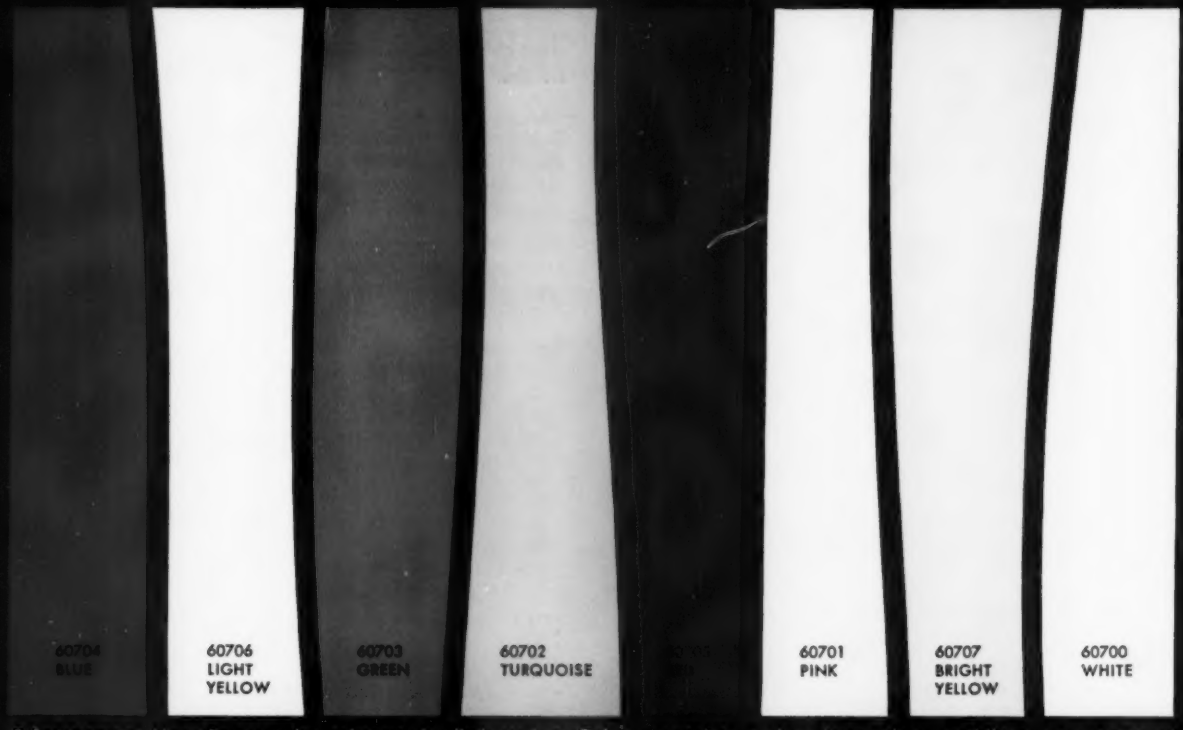
For more information, circle No. 509 ➤

Again Eastman leads the way in color—

with 8 TENITE POLYETHYLENE

Standard Color Concentrates



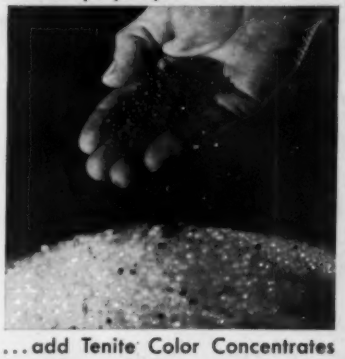
Advantages: Use of messy dry colorants is eliminated • Color uncertainty and contamination possibilities are minimized Easier and faster color changes are possible • Mixing time is reduced • Inexpensive mixer hoppers can be used

Tenite Polyethylene *Standard* Color Concentrates offer molders a quick, clean and sure means to color polyethylene for injection molding or continuous extrusion. The cost is usually less than a penny a pound when used in a 1-10 ratio with natural material. Lighter or darker shades, of course, can be obtained by varying this ratio. Also, by combining concentrates of different colors in ratios determined by experimentation, other attractive colors may be produced.

Because these concentrates consist of natural polyethylene resin in which coloring agents have been thoroughly predispersed, pigment agglomeration is virtually eliminated. The result: excellent, uniform dispersion of the color throughout the molded product.

Standard color concentrates are stocked for immediate shipment in 50-pound multiwall bags and in 10-pound polyethylene bags. Other concentrates are also available (at slightly higher cost) in an almost unlimited range of colors to satisfy any color request.

To color polyethylene .....



...add Tenite Color Concentrates

TENITE
POLYETHYLENE
an Eastman plastic

For prices and a set of molded 1-to-10 samples of our eight standard colors, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Fabricated by CDF. Near the presses that produced the Dilecto laminates, these paper-base parts were machined to close tolerances by CDF specialists . . . quickly, accurately, economically for the purchasers. This is a random selection from the five grades described in the table below.

CDF Dilecto® paper-base laminates for the workhorse insulation jobs

For everyday mechanical-electrical parts that receive tough punishment and must have excellent physical and dielectric properties at low cost, the CDF phenolic paper-base line is outstanding.

Economy. CDF paper-base grades machine readily into intricate parts. Some are flame-retardant. Others are especially adaptable for punching. All are economical for the value delivered.

Fabrication Facilities. CDF has excellent and extensive plastics-fabrication facilities for turning out finished Dilecto parts to your specifications—better and more economically than you can do it yourself. Save the time and trouble of intricate fabrication by using CDF's specialized facilities.

See Sweet's, Electronics Buyers' Guide, and the other directories for the phone number of the CDF sales engineer nearest you. Or send us your print or problem direct, and we'll return a recommendation of the right Dilecto grade for your need.

CDF makes Di-Clad* printed-circuit laminates, Diamond* Vulcanized Fibre, CDF products of Teflon†, flexible insulating tapes, Dilecto* laminated plastics, Celoron* molded products, Micabond* mica products, Spiral Tubing, Vulcoid*.

*Trademark of Continental-Diamond Fibre Corporation
†Du Pont trademark for its TFE-fluorocarbon resin

CONTINENTAL-DIAMOND FIBRE
A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 25, DEL.

Typical Property Values—Dilecto Paper-Base Laminates in Sheet Form

	X-13 (NEMA X)	XP-13 (NEMA P)	XX-13 (NEMA XX)	XX-13 FR (Fire-retardant) (NEMA XX)	XXXP-28 (NEMA XXXP)
ROCKWELL HARDNESS (M SCALE)	100	95	110	108	90
TENSILE STRENGTH lw (1000 psi.)	20	12	16	17	12
FLEXURAL STRENGTH lw (1000 psi.)	27	16	17	20	18
COMPRESSIVE STRENGTH (1000 psi.)	40	25	35	41	22
WATER ABSORPTION (% in 24 hrs.) 1/16" thickness	3.5	3.0	1.4	1.2	0.6
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (°C.)	120	120	120	120	120
DIELECTRIC STRENGTH perp. to lam. (VPM)	800	800	650	700	800
DIELECTRIC STRENGTH parallel to lam. (Kv.)	50	50	60	70	75
DISSIPATION FACTOR at 1 mc, Cond. A	0.042	0.038	0.034	0.038	0.027
DIELECTRIC CONSTANT at 1 mc, Cond. A	5.5	4.6	4.7	4.8	3.6
ARC-RESISTANCE (seconds)	8	4	4	10	10
INSULATION RESISTANCE (megohms) ASTM D-257, Fig. 3	100	100	1,000	1,000	600,000
AIEE insulation class	A	A	A	A	A

For more information, turn to Reader Service card, circle No. 403

For more information, circle No. 510 ➤

protection is stainless steel

Summer or winter the car with plenty of Stainless Steel
is easy to clean and keeps its good looks
under the roughest conditions of driving and weather.

No other metal offers the freedom of design and fabrication,
economy of care and the durable beauty that serves
and sells like Stainless Steel.

McLOUTH STEEL CORPORATION, Detroit 17, Michigan

specify

McLOUTH STAINLESS STEEL

HIGH QUALITY SHEET AND STRIP

for automobiles

STAINLESS STEEL SAYS "NO" TO SCRATCHES!

Old stuff? Perhaps, but it always bears repeating. For it's worth remembering that stainless steel not only resists scratching but is also resistant to rust and corrosion, is extra strong and doesn't peel. What's more it's beautiful—and it *stays* beautiful.

That's why the slogan, "Make it better, make it stainless," is as meaningful today as ever. Bear in mind, too: The very finest stainless steels are made with Vancoram Ferro Alloys.

Producers of alloys, metals and chemicals

VANCORAM

VANADIUM CORPORATION OF AMERICA

420 Lexington Ave., New York 17, N. Y.
Chicago • Cleveland • Detroit • Pittsburgh

For more information, circle No. 511 ➤

For more information, turn to Reader Service Card, circle No. 376

NAUGATUCK PARACRIL OZO

THE OIL-RESISTANT, OZONE-RESISTANT NITRILE RUBBER

Now–the finest wire jackets can be Colored!

FOR SALES APPEAL • FOR SERVICE EASE

New Paracril OZO—a superior rubber compound developed by Naugatuck—makes possible *new eye appeal, new ease of identification*. And it outperforms standard wire jacket compounds many other ways, too!

Compare new PARACRIL OZO with other wire jacket rubbers. Prove for yourself, new PARACRIL OZO gives:

- significantly superior ozone resistance
- greater fuel and oil resistance
- much greater abrasion resistance than standard jacket compounds
- excellent processability, with particularly fast extrusion
- *permanent retention of bright colors!*

If you are not already using PARACRIL® for your wire jacket compounds or similar products requiring such properties, chances are 1000 to 1 it's because you haven't yet *tried* PARACRIL OZO.

Why *not* try it—soon. Contact your nearest Naugatuck representative at the address below.

Naugatuck Chemical

Division of United States Rubber Company 741P Elm Street Naugatuck, Connecticut

US RUBBER

Rubber Chemicals · Synthetic Rubber · Plastics · Agricultural Chemicals · Reclaimed Rubber · Latices · CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario · CABLE: Rubexport, N.Y.

At Roamer,
Yoloy "E" sheets and plates are hand-formed (hammered) to shape, then welded to the boat's frame.

Accent on Excellence

Youngstown Yoloy "E" high-strength steel

Here's the answer to a sportsman's prayer—this elegant Roamer 42-foot Royal built by Roamer Steel Boats Division of Chris-Craft Corporation, Holland, Michigan.

Keels, hulls and decks are easily fabricated from Youngstown Yoloy "E" High-Strength, low-alloy steel to provide long, trouble-free service life in salt water. Roamer reports Yoloy's strength, flatness and excellent weldability contribute in no small measure to maintaining their reputation as one of the world's quality steel boat builders. Yoloy steels are available in sheets, plates, strip, shapes, hot rolled and cold finished bars—also as seamless and continuous weld tubular products.

Wherever high-strength steel becomes a part of things *you* make, the high standards of Youngstown *quality*, the personal touch in Youngstown *service* will help you create products with an "accent on excellence".

Send for free technical bulletin on Youngstown Yoloy "E" Steel.

QUALITY YOUNGSTOWN SERVICE

THE
YOUNGSTOWN
SHEET AND TUBE COMPANY

For more information, turn to Reader Service Card, circle No. 447

Manufacturers of Carbon, Alloy and Yoloy Steel, Youngstown, Ohio

SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER III—Lustrous, Corrosion-Resistant Finishing with Chemical Polishing Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are widely accepted throughout industry as an economical means of providing corrosion protection, a good base for paint and decorative finishes for non-ferrous metals. Certain of these coatings also possess chemical polishing abilities that have luster-producing, as well as corrosion-inhibiting, effects on zinc and cadmium plate, zinc die castings and copper alloys. However, continued developments in this field have been so rapid that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this discussion of the many ways in which this chemical polishing characteristic can be used in final finishing or pre-plating treatments to produce a lustrous appearance with distinct display and sales appeal and appreciable savings in cost. Report I on decorative, corrosion-resistant finishes and Report II on paint base corrosion-resistant finishes are available on request.

The degree of luster possible on a surface is a function of the degree to which the surface can be smoothed. Leveling to provide a smooth surface can be achieved by mechanical or chemical means, or a combination of these, depending upon the luster desired and the original condition of the metal. Chemical polishing effectively imparts luster otherwise difficult and costly to obtain. For this reason, it is often used to supplement or entirely replace mechanical polishing, depending upon the application and the original condition of the metal. Chemical polishing has the additional advantage of providing overall treatment of the submerged part. It reaches into even the deepest corners and recesses that are otherwise inaccessible. Certain of the Iridites are specifically designed to perform this chemical polishing operation. Also, they provide corrosion protection as do all Iridites, thus may be used as a final finish or a pre-plating polish.

If Iridite is to be used as a final finish, in contrast to pre-plating treatment, the chromate conversion coating generated is allowed to remain, providing good corrosion resistance. Color inherent in these Iridite films ranges from a yellow cast to yellow iridescent. These coatings may be used without further treatment where this color is acceptable and good corrosion resistance is desired. Further, these basic coatings can be tinted by dyeing. Among the dye tints available are shades of red, yellow, blue and green. If desirable, the basic coatings can also be modified by a bleach dip leaving a clear bright or blue iridescent finish. In all cases bleaching reduces corrosion resistance.

As examples of this type of final finishing, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, lustrous chemical polishing of the as-cast surface of zinc die castings. Thus, in many cases, sizeable savings in finishing cost are realized by elimination of plating costs. This economical method can be used on tools, appliance parts, toy pistols, locks and many other small castings. Another example is the treatment of copper and brass parts, such as welding tips, to eliminate buffing and provide additional corrosion resistance. In many cases, handling costs are reduced appreciably by replacing piece-part handling with bulk processing. Still another example of the use of this chemical polishing and protective quality of Iridite is a simple system of zinc plate, Iridite and clear lacquer instead of more costly electroplated finishes. Typical of this type of lustrous finish are builders hardware and wire goods.

As a pre-plating treatment, in contrast to final finishes, Iridite can be used to chemically polish zinc die castings or copper prior to plating. In such cases, Iridite should be applied as an in-process step, so that the protective film is removed before the plating cycle. The savings in handling, material and labor costs are obvious. This process has made it practical to plate chrome directly over copper on steel, conserving nickel, yet producing a lustrous chrome finish. Used after stripping faulty plate in reprocessing zinc die castings, Iridite restores luster to the casting, thus making possible replating without blistering.

Other Iridite finishes are available to produce maximum corrosion resistance, a wide variety of decorative finishes and excellent bases for paint on all commercial forms of the more commonly used non-ferrous metals. As a final finish, appearance ranges from clear bright to olive drab and brown and many films can be bleached or dyed. As a paint base Iridite provides excellent initial and retentive paint adhesion and a self-healing property which protects bare metal if exposed by scratching. Iridites have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of their top performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product demands the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

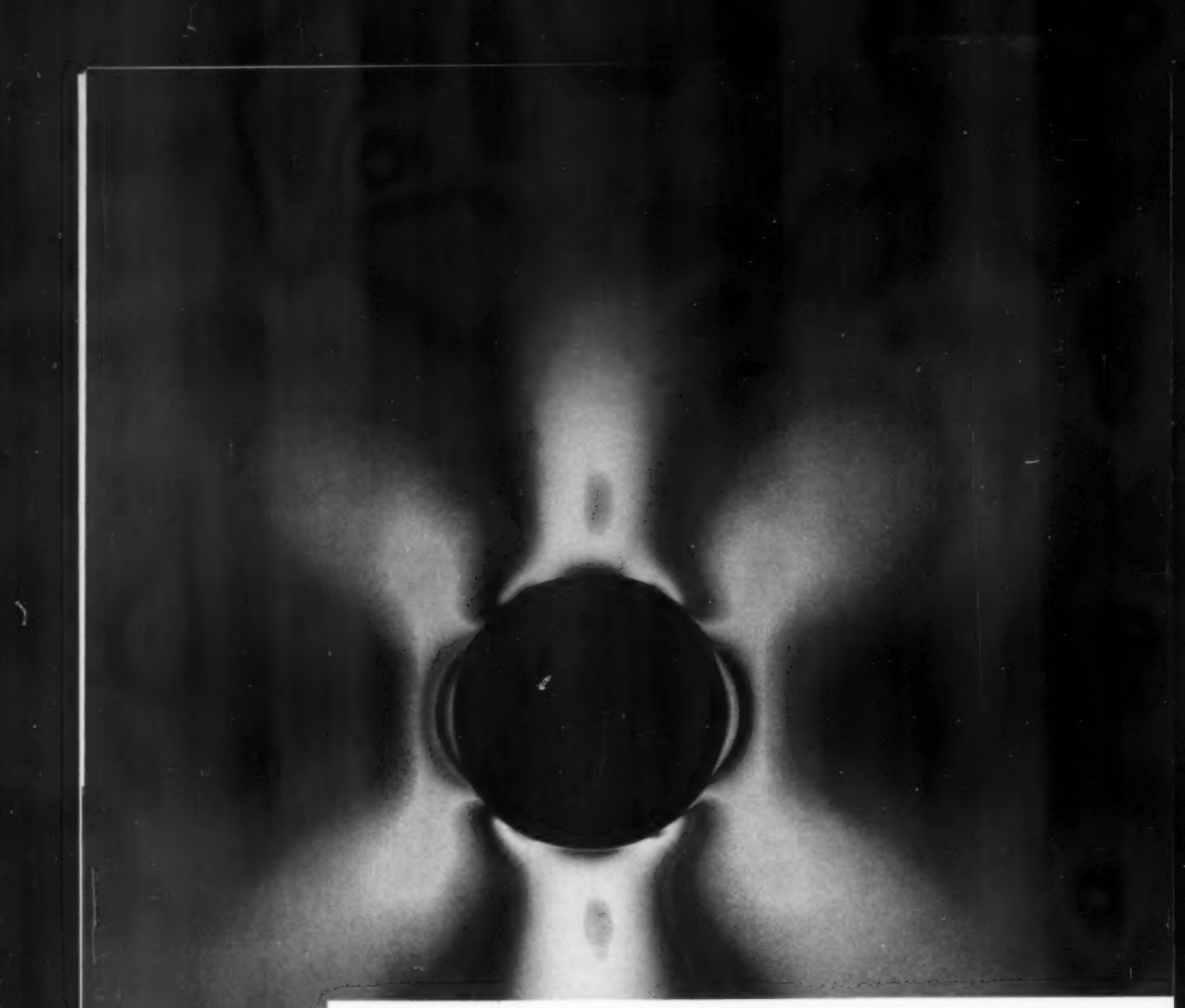


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

Strength is Malleable

The strength crucial in spiraling the heave of diesels' pistons into unresistible power, in protecting lives as automobiles hurtle down endless highways, and in every link of chain that swings massive loads overhead, is yours to mold into tomorrow's dynamic engineering achievements with Malleable iron castings. Yet Malleable provides this strength in combination with toughness, producibility and economy that makes Malleable castings the finest, most versatile metal available.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

(Advertisement)

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ILLINOIS
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Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
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Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
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Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Get More Strength Per Dollar with Malleable Castings

With few exceptions, strength is the most important single design requirement for a metal part. But in the commercial production of that part, the ultimate objective is to manufacture it at the lowest possible cost. Malleable iron castings take advantage of many factors to provide the greatest strength per dollar of any ferrous or non-ferrous metal.

Great Strength Range Available

From the wide range of standard (ferritic) and pearlitic Malleable irons available, a type may be selected that meets strength requirements ranging from 50,000 p. s. i. to 120,000 p. s. i. tensile.

Table No. 1 shows these strength values and other physical measures for 9 grades of Malleable. Note particularly how high yield strengths are in comparison to tensile strengths. Because yield strength is generally the measure of usable strength, this is especially important.

Also important is the uniformity of Malleable's strength. The heat treatment given all Malleable castings produces a unique metallurgical combination of strength, ductility, machinability and impact resistance. At the same time, it relieves internal stresses so that Malleable's strength cannot be machined away, nor will it be present in some parts but missing in others.

TABLE No. 1
TENSILE PROPERTIES—
A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Ratio of Tensile to Yield %
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Economy Due to Multiple Factors

Malleable's superior strength-cost ratio is due to a combination of the casting process, which puts the metal where you want it, and the inherent economy of Malleable iron. Also, whenever machining operations are involved, Malleable castings cut finished costs significantly. Being the most easily machined of all ferrous metals of similar hardness, the cost of the finished part can often be reduced to less than that of metals which cost less in the semi-finished stage.

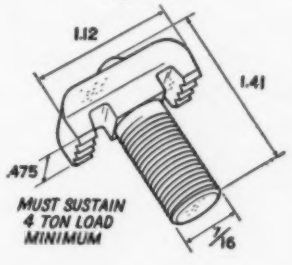
Malleable Provides Strength Plus Other Advantages

The T-bolt shown in Fig. 1 is used to assemble steel channel frames. Small but mighty, these 7/16″ bolts hold 4 ton loads. The tensile strength requirements are 90,000 to 100,000 p. s. i., yet ductility must be good and tolerances must be held to ±.005″ on the head width, and +.020″, —.000″ on the inside of the head.

In this application, pearlitic Malleable castings proved the only material consistently capable of sustaining loads over 8,000 pounds and meeting close tolerances in critical areas. At the same time, sufficient ductility was maintained to allow upsetting the spring retainer protrusion on the head.

The finished Malleable castings cost one third less than the next most satisfactory material. For both dynamic and static applications, today's Malleable castings are truly one of industry's finest engineering materials.

Fig. No. 1



Write for Free Data Unit

Data Unit 102-Strength, more fully describing Malleable's strength characteristics, is available for use by materials specifiers and users. For your copy, contact any member of the Malleable Castings Council or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

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for strength,
corrosion
resistance
and safety...

it had to be Stainless

This window washer anchor is fabricated from Carpenter Stainless No. 4-A (Type 304) for use with window hardware on skyscrapers in large cities. Men attach their safety belts to these anchors while washing the windows. Stainless is used for maximum corrosion resistance and strength in atmospheric conditions. In fabrication, the forging bars must flow freely without tendency to rupture. Since switching to Carpenter, the forging shop has reduced rejections because of the cleaner, defect-free surfaces. The Carpenter representative near you can supply close metallurgical cooperation and complete technical data on your stainless requirements. The Carpenter Steel Company, 135 W. Bern Street, Reading, Pa.

Carpenter STEEL

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Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

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✓ check these cost-cutting NEW IDEAS from SETKO

then check the coupon below for full information and free test samples

IDEA #1 "NU-CUP® POINT GRIPS THINWALL TUBING BETTER THAN ALL OTHERS TESTED!"

42% sharper angle on point cuts deep into the metal in a circular manner!

An independent manufacturer tested all types of points to find the one that would hold best . . . and perform most dependably. He chose NU-CUP. Could you use this idea? Check No. 1. (Name of Mfr. on request.)

Set Screw & Mfg. Co.

IDEA #2 THIS COST-CUTTER TAKES 50% MORE TORQUE BECAUSE OF SLABBED HEAD CONSTRUCTION!

Costs less than comparable hexagon head set screws.

If you are having trouble with stripped heads or insufficient holding power, chances are the Setko Slabbed Head Set Screws are just the idea you need . . . Available in all points and metals. Check No. 2!

Set Screw & Mfg. Co.

IDEA #3 IS VIBRATION CAUSING LOOSE SET SCREWS ON YOUR PRODUCTS? . . . ELIMINATE THIS PROBLEM WITH ZIP-GRIP®!

Slight variation of thread causes locking action on mating surface!

Proven as an outstanding principle in many products, Zip-Grip has found particular acceptance wherever the stress of movement or vibration occur. Makes an outstanding adjusting screw . . . Can be reapplied many times . . . Got an idea? Check No. 3.

Set Screw & Mfg. Co.

IDEA #4 TINY SCREWS DO BIG HOLDING JOB . . . THEY'RE CALLED "MINI-MITE"

You'll find them perfectly-produced counterparts to their big brothers!

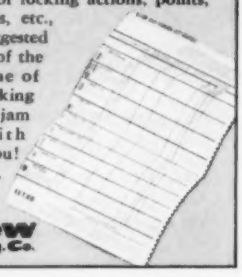
If miniaturization is one of the fields that you're interested in, then you'll see many good ideas in the perfectly-produced, money saving selection of Mini-Mites . . . Why pay for Specials when these can keep your costs at a minimum . . . Get the idea? Check No. 4.

Set Screw & Mfg. Co.

IDEA #5 NEW SELF-LOCKING SET SCREW SELECTOR CHART LISTS OVER 1,001 COMBINATIONS.

Helps you determine available combinations best for your particular application!

Here is another Setko first . . . A complete listing of locking actions, points, metals, drives, etc., including suggested applications of the complete line of Setko self-locking screws . . . It's jam packed with ideas for you! Check No. 5.



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IDEA #6 "SETKO HOPPER FEEDER SAVED US $42,000 IN FIRST YEAR."

Here's the first truly Automated method of hopper feeding Headless Set Screws.

Unique Setko Hopper Feeder design orients headless Set Screws then feeds them to a driving device . . . Savings like the one shown above are but one of the advantages (name of mfr. on request) . . . Product quality is consistent, etc. This cost-cutting idea is one you can't miss! Check No. 6.

Set Screw & Mfg. Co.

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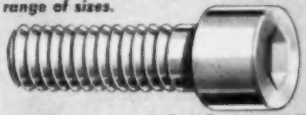
IDEA #7 NEW LINE OF COLD FORGED "PERFECT HOLE" CAP SCREWS PRECISION MANUFACTURED!

Specially-designed machinery produces uniformly perfect cap screws in wide range of sizes.



If you're a user of Cap Screws you'll want to examine these yourself . . . We know you'll get our idea of trying to produce a perfect product consistently . . . We're sure you'll appreciate their performance once you've tried them . . . Would you like test samples? We'll be glad to send them! Check No. 7 and indicate sizes, etc.

Set Screw & Mfg. Co.

IDEA #8 THERE'S A BARREL-FULL OF IDEAS IN THE NEW 28-PAGE SETKO CATALOG #23.

The complete line of cost-cutting SETKO Socket Screw Products is at your fingertips.

You'll want this compact catalog for your personal use . . . And you'll particularly like the easy to read manner in which it has been prepared. Want a copy? Check No. 8.

Set Screw & Mfg. Co.

Set Screw & Mfg. Co.

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Please send me Idea information on items checked below. (If FREE samples are wanted of any of these products, send your specifications).

- ☐ 1. Nu-Cup
- ☐ 2. Slabbed Head
- ☐ 3. Zip-Grip
- ☐ 4. Mini-Mite
- ☐ 5. Self-Locking Selector Chart
- ☐ 6. Hopper Feeder
- ☐ 7. Cap Screw
- ☐ 8. Catalog

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ADDRESS _____

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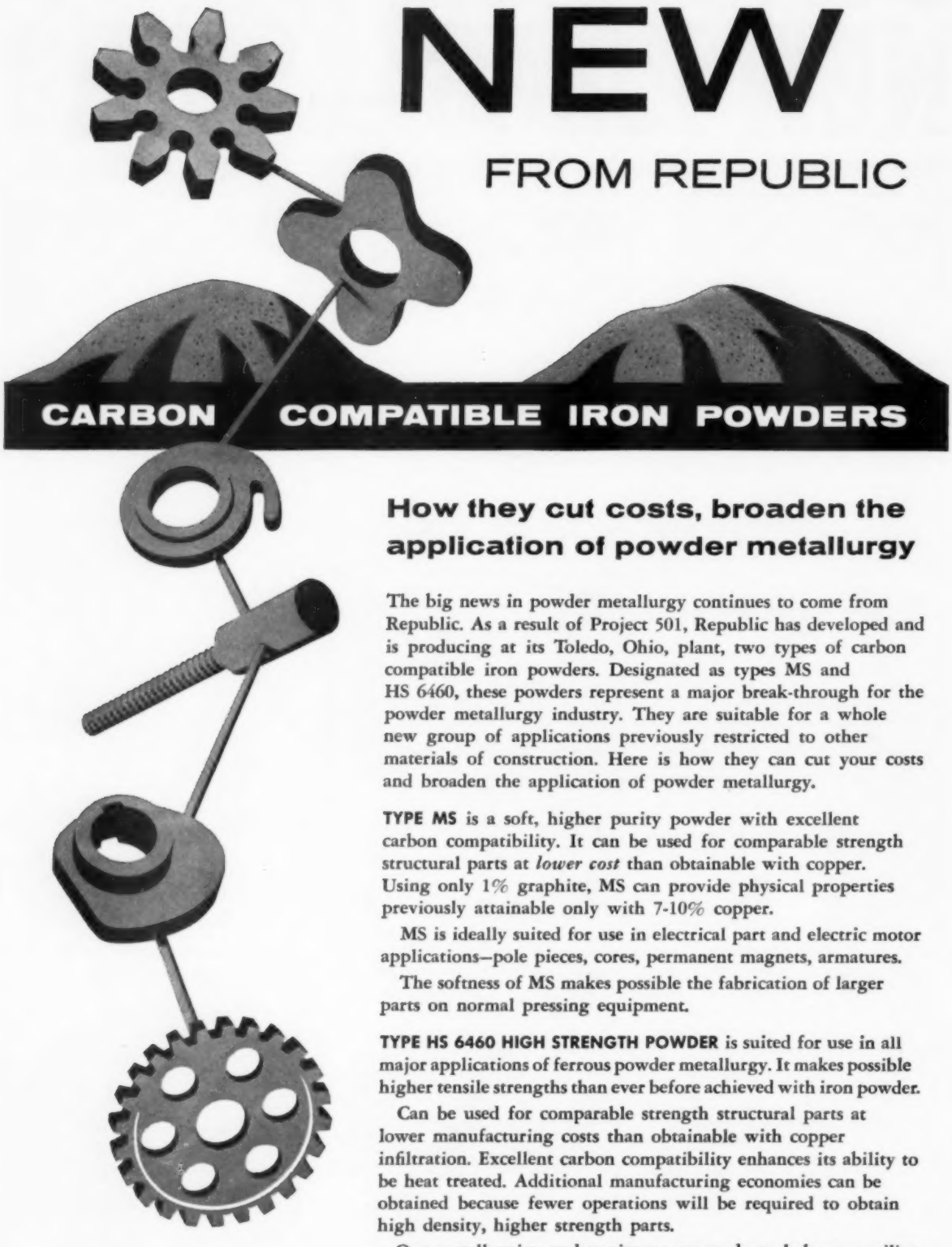


How they cut costs, broaden the application of powder metallurgy

The big news in powder metallurgy continues to come from Republic. As a result of Project 501, Republic has developed and is producing at its Toledo, Ohio, plant, two types of carbon compatible iron powders. Designated as types MS and HS 6460, these powders represent a major break-through for the powder metallurgy industry. They are suitable for a whole new group of applications previously restricted to other materials of construction. Here is how they can cut your costs and broaden the application of powder metallurgy.

TYPE MS is a soft, higher purity powder with excellent carbon compatibility. It can be used for comparable strength structural parts at *lower cost* than obtainable with copper. Using only 1% graphite, MS can provide physical properties previously attainable only with 7-10% copper.

MS is ideally suited for use in electrical part and electric motor applications—pole pieces, cores, permanent magnets, armatures.

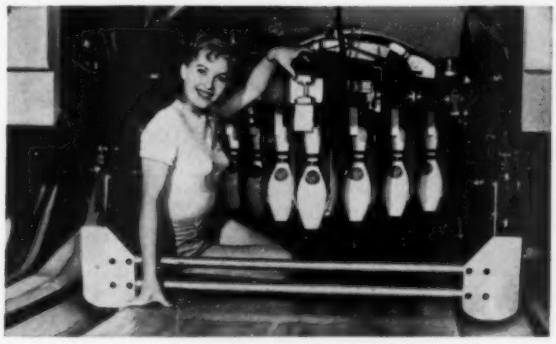
The softness of MS makes possible the fabrication of larger parts on normal pressing equipment.

TYPE HS 6460 HIGH STRENGTH POWDER is suited for use in all major applications of ferrous powder metallurgy. It makes possible higher tensile strengths than ever before achieved with iron powder.

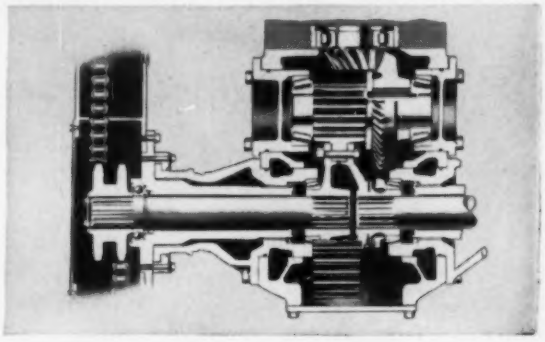
Can be used for comparable strength structural parts at lower manufacturing costs than obtainable with copper infiltration. Excellent carbon compatibility enhances its ability to be heat treated. Additional manufacturing economies can be obtained because fewer operations will be required to obtain high density, higher strength parts.

Our metallurgists and engineers are ready to help you utilize all the advantages of Republic Carbon Compatible Powders. Just mail the coupon to obtain their services, or for technical data sheets on Type MS and Type HS 6460 Powder.

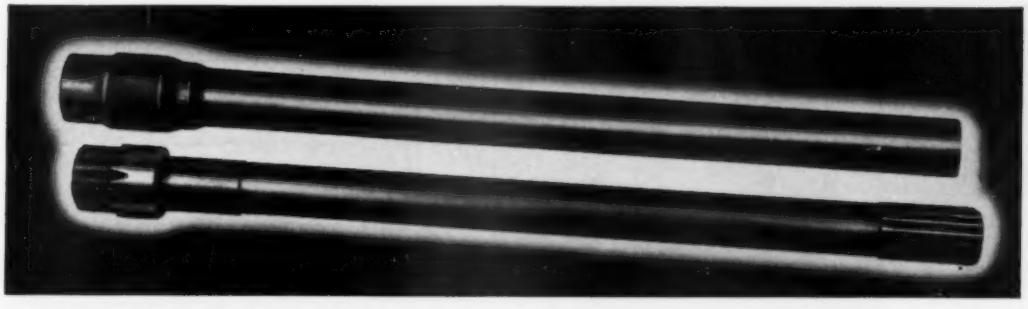
other Republic products for designing and engineering



AMF CUTS COSTS, builds a better pinspotter with Republic ELECTRUNITE® Mechanical Tubing. On the initial order, ELECTRUNITE saved American Machine & Foundry Company, Brooklyn, New York, $34,000 in manufacturing their famous AMF Automatic Pinspotter. AMF was able to eliminate boring and grinding operations because ELECTRUNITE met O.D. tolerance requirements. This feature resulted in a savings of $15,000 in fabricating operations. Another $19,000 was saved on the cost of ELECTRUNITE as compared with tubing previously used. In uniformity, quality, original costs, Republic ELECTRUNITE Mechanical Tubing can save you time and money, too. Call Republic, or mail coupon for facts.



EXCEPTIONALLY HIGH STRENGTH-TO-WEIGHT RATIOS plus resistance to fatigue, stress, shock, and impact are values of Republic Alloy Steels that equipment builders have been relying on for years. Engineers and metallurgists of the Adams Division, LeTourneau-Westinghouse Company, for example, spent thousands of hours on research and testing of all types of steels to find one that would reduce ultimate fatigue to an absolute minimum in the drive axle of their "660" Motor Grader. They selected Republic Hot Rolled 4340 Alloy Steel. This fine steel not only resists fatigue, but also is able to take high torque without a permanent set. Specify Republic Alloy Steels where strength and toughness must resist heavy-duty roughness. Our metallurgists will help you.



NEW FABRICATING PROCESS MEANS ECONOMY. Ford Tractor power take-off counter-shafts cost less to produce using Republic Die-Form blanks, as compared with previous materials. Blank is shown on top . . . completed shaft below. Die-Form is a new method of cold forming hot rolled carbon, alloy, or stainless steel bars into multi-diameter blanks ready for final machining. Since Die-Form blanks closely approximate the completed part, final machining is minimized. Handling costs for raw material and scrap disposal are reduced—production rates increased. Die-Form Process improves machinability of any given steel analysis. Permits further savings through use of higher feeds and speeds. Mail coupon for complete facts.

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Send more information on: ☐ MS Powder ☐ HS 6460 Powder ☐ Die Form ☐ Alloy Steel ELECTRUNITE Tubing

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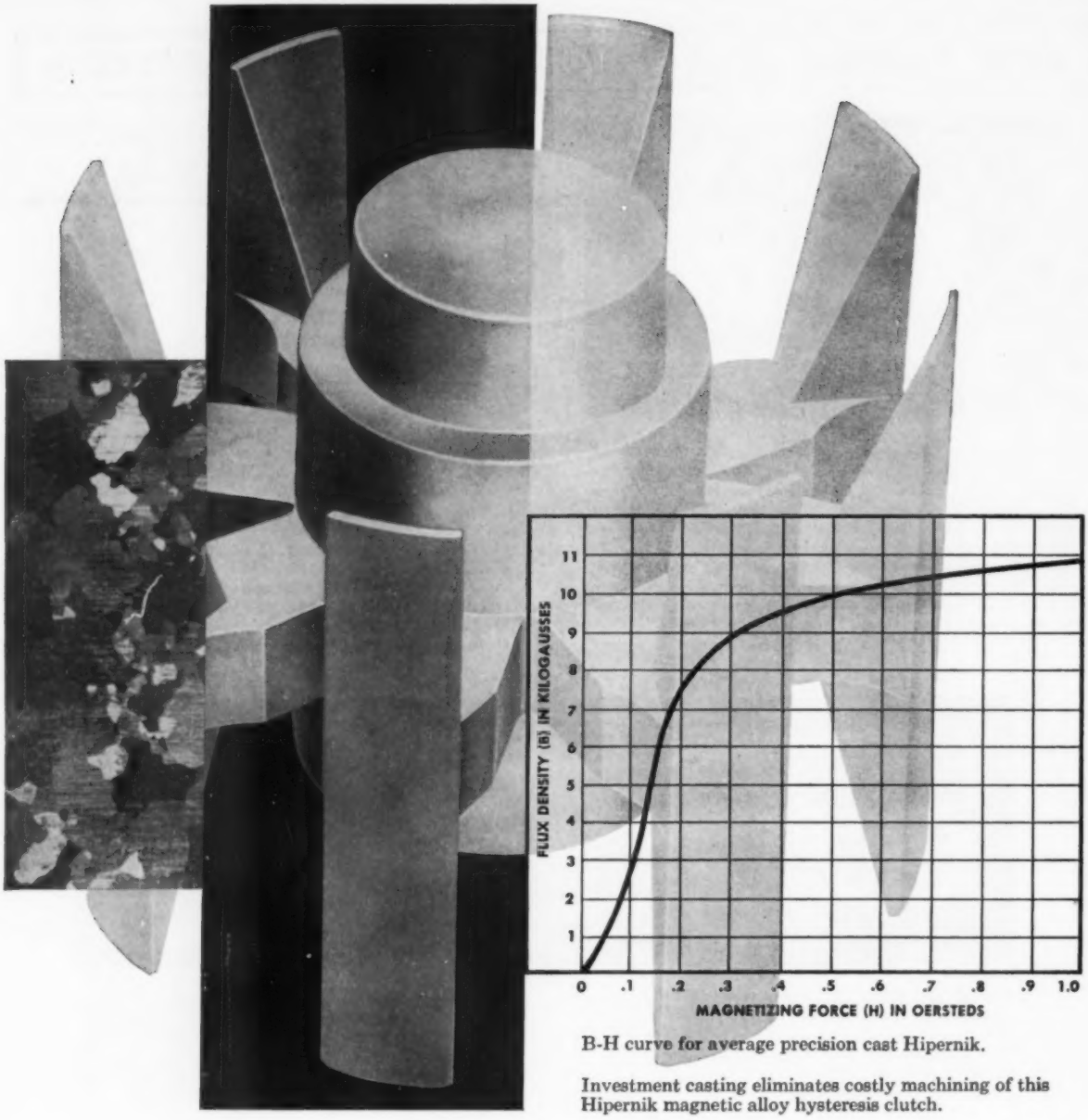

B-H curve for average precision cast Hipernik.

Investment casting eliminates costly machining of this Hipernik magnetic alloy hysteresis clutch.

Westinghouse Hipernik Casting

. . . cuts costs, retains magnetic properties

The field of electronics has created special metal problems. The Westinghouse Metals Plant has accepted and solved some of these problems.

Cast Hipernik® is particularly adaptable to the requirements of missile control systems. Other applications in the electronic control and instrumentation fields are transformer cores, pole pieces, solenoids, torque motors, magnetic clutches and many special magnetic applications.

The Westinghouse Metals Plant may be able to cut your costs by eliminating unnecessary machining, yet delivering to you a completely finished component ready for assembly. This modern metals plant can furnish strip, sheet and bar stock in other magnetic and high temperature alloys. Write to: Westinghouse Metals Plant, Blairsville, Pennsylvania. Our latest bulletin on Hipernik will be sent to you by return mail. J-05005

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS-TV MONDAYS

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WHY ARMCO 17-7 PH STAINLESS HELPS ASSURE PRECISION PERFORMANCE AND LOW COST FOR ELECTRIC SWITCHES

A leading manufacturer of subminiature, small industrial and commercial, and precision electric switches recently specified Armco 17-7 PH Stainless Steel for the center blades and patented rolling springs in many of their products. A non-ferrous spring material was replaced with 17-7 PH Stainless because its unusual characteristics offered the opportunity to improve the reliability and performance of their switches at low cost. The mechanical life of one part was increased from 30,000 to 30,000,000 cycles!

Using this special material in the hard temper condition, they obtained:

Ultimate tensile strength of 220,000 psi
Tensile yield strength of 190,000 psi
Fatigue strength of about 85,000 psi at 10^7 cycles
Good corrosion resistance, much superior to that of the hardenable chromium grades of stainless steels.

Where even greater strength is needed, Armco 17-7 PH hard temper (Condition C) sheet and strip can be heat treated to a typical ultimate tensile strength of 265,000 psi. And, if parts require extensive fabrication, they can be easily formed from annealed 17-7 PH then hardened to high strength and hardness.

Improve the reliability and performance of your products by using 17-7 PH Stainless Steel for parts that require high strength and hardness up to 900 F, good corrosion resistance, and excellent fabricating characteristics. Armco 17-7 PH is available in sheets, strip, plates, bars, and wire; a companion grade, Armco 17-4 PH in bars, wire, and billets.

Just fill out and mail the coupon for complete information on the properties and fabrication of these special stainless steels.

Armco Steel Corporation
1609 Curtis Street, Middletown, Ohio

Send me information on: ☐ Armco 17-7 PH Stainless Steel ☐ Armco 17-4 PH Stainless Steel

We are considering these materials for the following applications:

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ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

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zero plus

. . . and Carlson special stainless steels withstand the extremes of another launching

WHEN this missile "lifts off," Carlson special stainless steel plates help launch it into space. These plates are the high strength, precipitation-hardening grades. And there are sound reasons why these grades are used.

First, with Armco 17-4PH, 17-7PH and PH15-7 Mo* it is easier to attain the high physical properties and resistance to elevated temperatures required in space flight engineering. Simplified low temperature heat treatment will develop a Rockwell hardness of C40 to C50. Tensile strengths, so vital in missile components, range from 180,000 to 220,000 psi in plates.

Second, only Carlson produces these Armco grades in the heavier plate thicknesses. For applications where high strength at high temperatures and ease of fabrication are important, get plates in these grades from Carlson. We will be glad to work with you on specific applications.

*17-4PH, 17-7PH and PH15-7 Mo are trade marks of Armco Steel Corporation

G. O. CARLSON Inc.

Stainless Steels Exclusively

126 Marshallon Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES
FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)

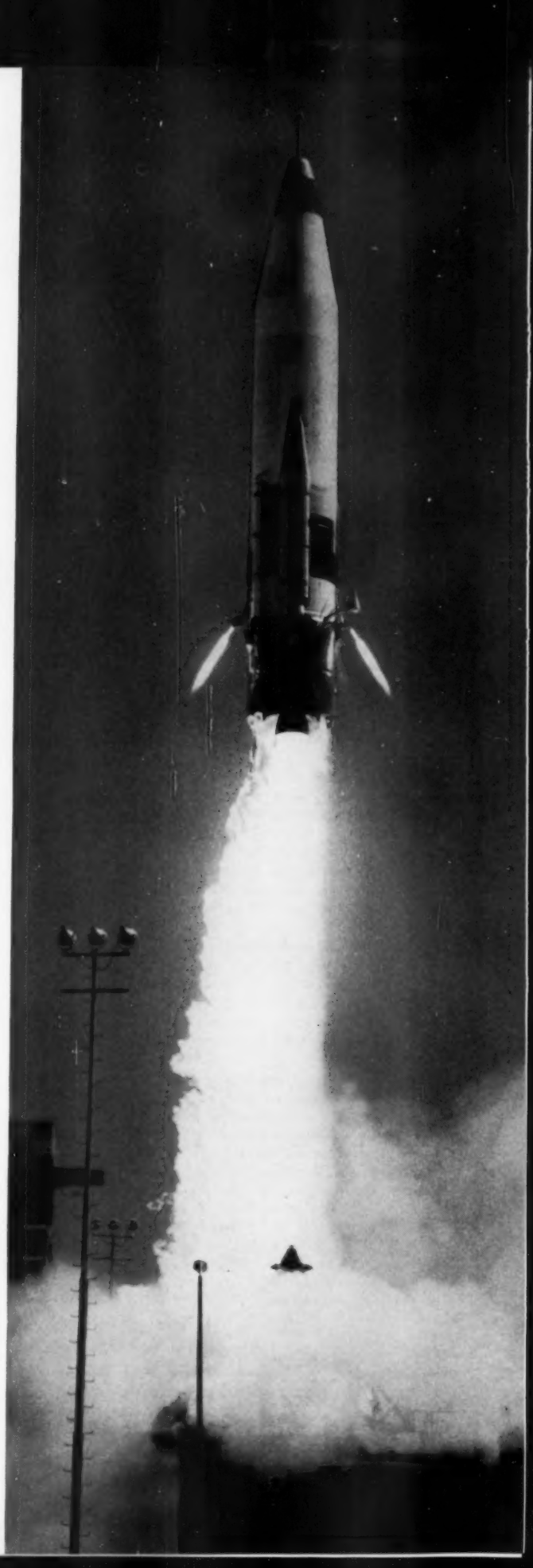

Photo of Atlas missile courtesy
CONVAIR ASTRONAUTICS,
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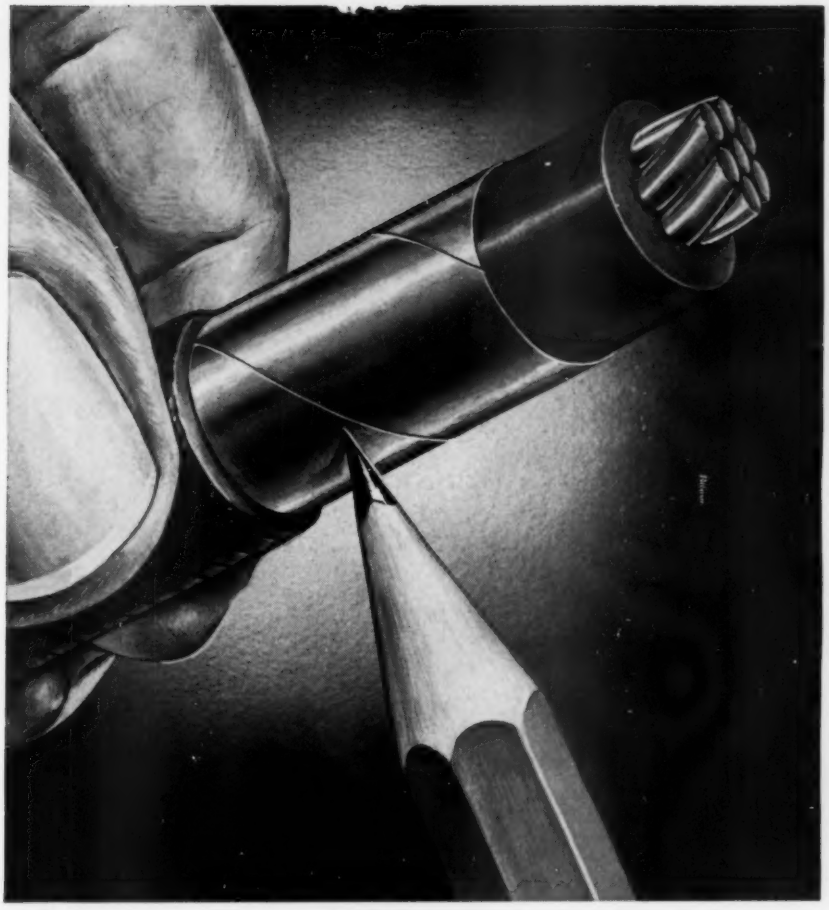

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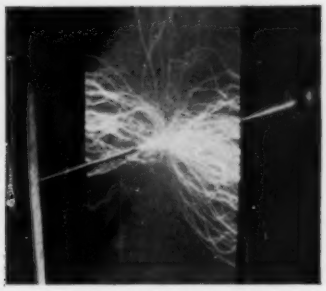

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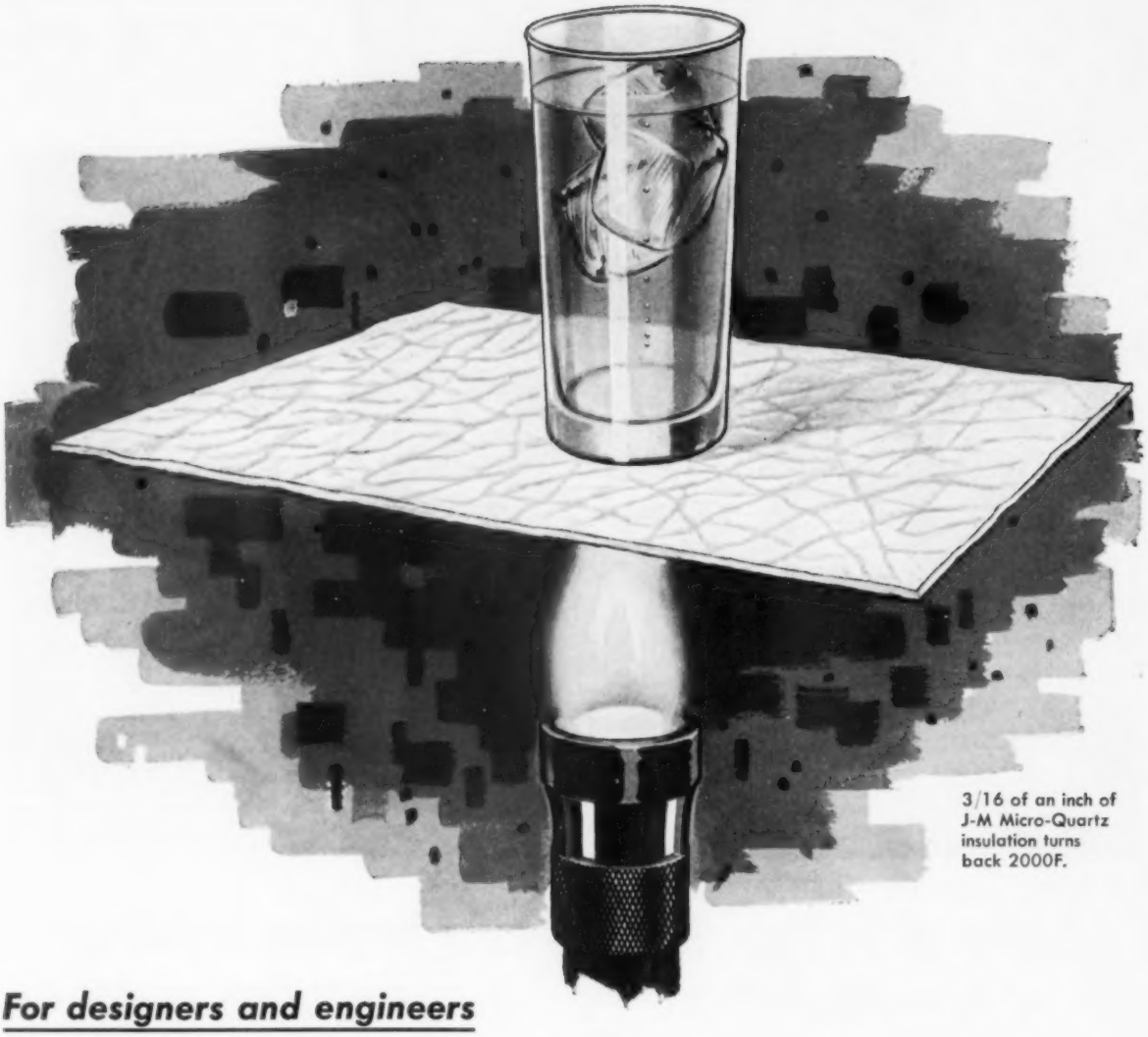

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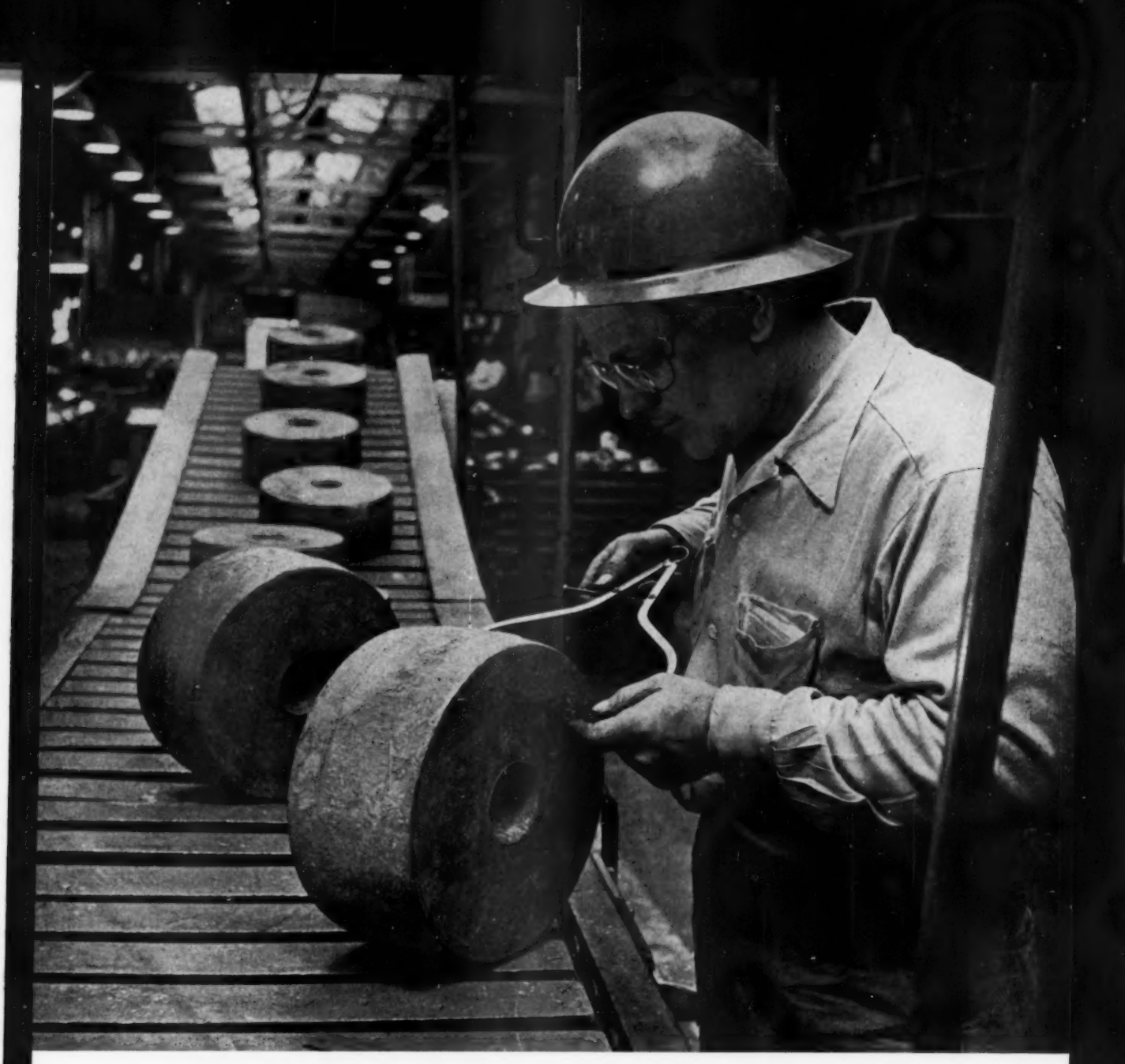

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Jet and missile developments *require that property data be extrapolated to ever higher temperatures.*

Which Method for Extrapolating Stress-Rupture Data?

This comparison of three different parameters and master curves shows:

- *How well they correlate original data*
- *How accurately they can be extrapolated*

by R. M. Goldhoff,
General Electric Co.

■ The parameters investigated here are the Larson-Miller, the Dorn and the Manson-Haferd. The methods used are mainly graphical and therefore subject to individual judgment. With this reservation, and within certain limitations to be discussed later, the following conclusions seem to hold:

1. Long-time stress-rupture behavior should not be predicated from data based on less than a 1000-hr span.
2. The Manson-Haferd parameter provides the best correlation of test data.
3. The Manson-Haferd parameter allows the most accurate extrapolation.
4. Master curve extrapolations compare better with *straight-line* isothermal-curve extrapolations than with *curvilinear* extrapolations.
5. Using optimum values of the Larson-Miller C yields more accurate master curves than using $C = 20$.

This study was limited to data obtained on four ferrous alloys: S-590, Nimonic 80A, A-286 and 1 Cr–1 Mo–0.25 V. The data, curves and evaluation steps to be given here refer mostly to S-590, but the conclusions stated above are based on similar analysis of all four alloys.

Determining the parameter constants

After obtaining test data (Table 1) and plotting isothermal stress-rupture curves (Fig 1), the first step is to determine the optimum value of the constants needed in the parameter equations. These equations, and the derived constants, are given in Table 2. The

constants were derived by plotting the graphs of Fig 3, 4 and 5. (These graphs are easily plotted by first plotting the intermediate graph of Fig 2.) The theory behind this method of determining the constants is as follows:

Larson-Miller. A constant stress plot of log t vs $\frac{1}{T+460}$ should produce a series of straight lines ($\log t = \frac{P}{T+460} - C$) converging to a single point when $\frac{1}{T+460} = 0$. At this point $C = -\log t$ or (for alloy S-590) +17. Because *20* is the value generally used for C, results based on both $C = 20$ and the determined value of C have been tabulated in Tables 3, 4 and 5.

Dorn. A constant stress plot of log t vs $\frac{1}{T+460}$ should produce a series of parallel straight lines whose slope is proportional to ΔH (taking ln of equation yields $\ln t = \ln \theta + \Delta H/RT_K$. The slope (4.05) is actually equal to ΔH divided by R (gas constant; 1.98) x ln 10 (converts log base from 10+0 e: 2.303) x temperature scale conversion factor (T_K is kelvin, T + 460 is rankine; 5/9). Thus the optimum value of ΔH is determined to be 102,500.

Manson-Haferd. A constant stress plot of log t vs T should produce a series of straight lines ($\log t = \frac{T}{P} + \log t_a - \frac{T_a}{P}$) converging when $T = T_a$ and $t = t_a$. Thus, for alloy S-590, $T_a = -150$ and $t_a = 20$. Because this relationship between log t and T is direct, rather than inverse as with the other parameters, the Manson-Haferd parameter is often referred to as the "linear parameter."

Comparing deviations of master curves

Master curves (stress vs parameter, Fig 6), though shown only for alloy S-590, were drawn for each alloy by substituting the test data of Table 1 into a parameter equation and using optimum values of constants as determined for each alloy. Although only one is necessary, five master curves were drawn for each alloy and each parameter. The purpose was to compare results obtained from master curves based on varying time spans of data.

The actual rupture time for each data point in Table 1 was compared with the rupture time calculated from each master curve by substituting the temperature and stress values for corresponding points.

These results are tabulated in Table 3. The consistently lower deviations of the Manson-Haferd parameter indicate that it has the greatest ability to correlate the actual test data. In addition,

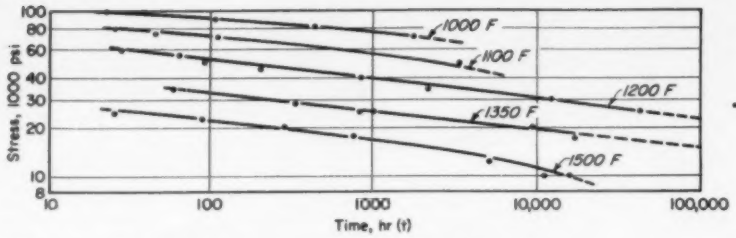


***Fig 1**—Isothermal plot of stress-rupture data of Table 1.*

TABLE 1—STRESS-RUPTURE DATA*

Temp, F	Stress, 1000 psi	Rupture Time, hr	Elong, %	Red. of Area, %
1000	70	1,677	18	13
	80	433	13	17
	90	109	14	19
	100	22	7	22
1100	50	3,149	16	24
	60	264	14	20
	70	109	23	25
	75	44	19	25
	80	25	26	22
1200	25	43,978	24	40
	30	11,937	18	20
	35	2,243	27	32
	40	756	26	31
	45	192	23	25
	50	93	23	24
	55	63	20	29
	60	26	23	32
1350	17.5	16,964	12	22
	20	9,529	11	17
	25	809	29	47
	25	1,028	21	41
	28	342	24	31
	34	59	19	28
1500	10	15,335	17	19
	10	11,257	6	14
	12.5	5,052	10	23
	15	1,352	19	31
	15	1,356	20	32
	17.5	719	18	26
	20	267	16	26
	22.5	88	15	23
	25	25	16	31

*Data for alloy steel S-590 heat treated 1 hr at 2275 F, water quenched, aged 16 hr at 1400 F, air cooled.

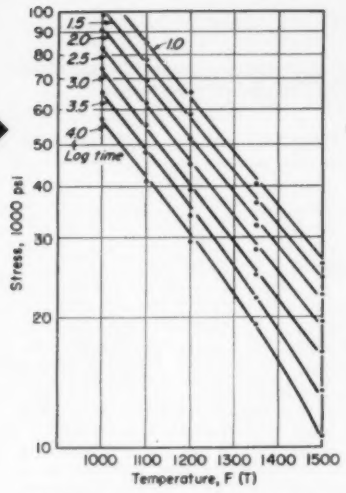


Fig 2—*Isochronal curves derived from Fig 1. Graph is an intermediate step from Fig 1 to either Fig 3 or 4.*

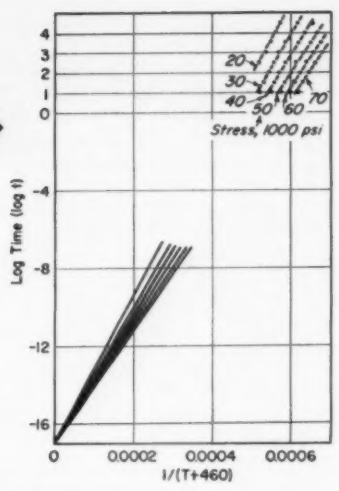


Fig 3—*Constant stress curves derived from Fig 2 and faired to intersect at $1/T+460 = 0$ where $C = -\log t$. Graph indicates that optimum value of C (Larson-Miller) for alloy S-590 is +17.*

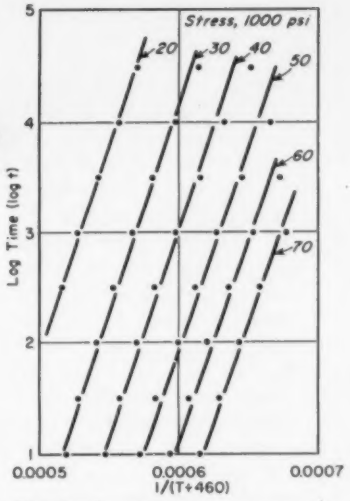


Fig 4—*Constant stress curves derived from Fig 2 and faired parallel. Graph indicates that optimum value of ΔH (Dorn) for alloy S590 is 102,500. Value is determined from slope (see text).*

Determining Values of Constants for the Three Parameters

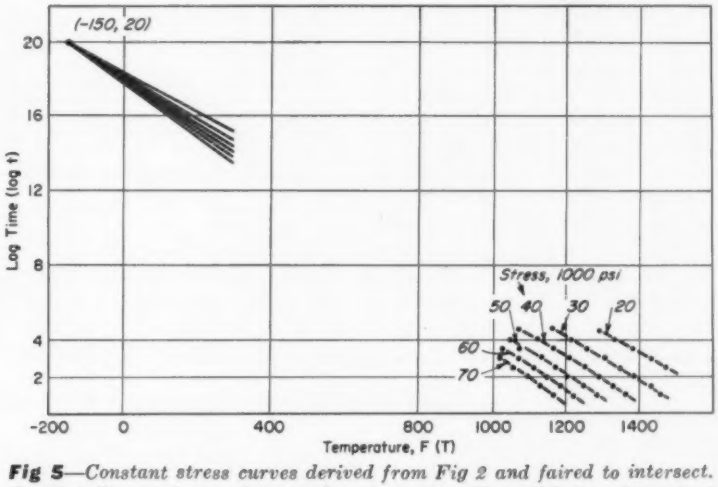


Fig 5—*Constant stress curves derived from Fig 2 and faired to intersect. Graph indicates that optimum value of constant "log t_a" is 20, of constant "T_a" is −150 (Manson-Haferd), for alloy S-590. In this case log time vs temperature (rather than temperature reciprocal) is a linear relationship.*

use of the optimum value of *C* in the Larson-Miller parameter (rather than C = 20) will often give better correlation (about equal for 1 Cr–1 Mo–0.25 V), although never as good as the linear parameter of Manson-Haferd.

Comparing errors in extrapolation

Each master curve was extrapo-

TABLE 2—PARAMETERS USED TO OBTAIN MASTER CURVES

Parameter ➡	Larson-Miller[a]	Dorn	Manson-Haferd
Equation and Symbols	$P = (T+460)(\log t + C)$ T = temperature, F t = rupture time, hr	$\theta = te^{\frac{-\Delta H}{RT_k}}$ T_k = temperature, K t = rupture time, hr R = gas constant = 1.98	$P = \frac{T-T_a}{\log t - \log t_a}$ T = temperature, F t = rupture time, hr
Calculated Values of Constants			
S-590	C = 17 or C = 20	ΔH = 102,500	$T_a = -150$, $\log t_a = 20$
A-286	C = 20	ΔH = 91,000	$T_a = 200$, $\log t_a = 16$
Nimonic 80A	C = 18 or C = 20	ΔH = 91,000	$T_a = 100$, $\log t_a = 16$
1 Cr-1 Mo-¼V	C = 22 or C = 20	ΔH = 110,000	$T_a = 100$, $\log t_a = 18$

[a]As indicated below, the study was carried through with two values of *C* for each alloy — 20 is the commonly accepted value; the other is termed the "optimum" value.

lated to a very long time at certain temperatures to determine the rupture stress. These stress values were compared with those obtained by straight-line extrapolation of the original isothermal curves. (The extrapolated parts are indicated by dashed lines in Fig 1 and 6.) Errors thus computed for alloy S-590 are tabulated in Table 4; those for 1 Cr–1 Mo–0.25 V are represented by values preceding the commas in Table 5; errors for the other two alloys are not tabulated here.

A study of these tabulations for all four alloys indicates that the linear parameter of Manson-Haferd can be expected to give closer and more conservative predictions of stresses for very long times. This is generally true although there are certain instances, i.e., certain alloys, time ranges or temperatures, where either the Larson-Miller or Dorn parameters may yield more accurate extrapolations.

Because isothermal curves are often extrapolated as a curve rather than a straight line, this method was also used to obtain "correct" values of stress. Comparing extrapolations of the master curves with such values for the 1 Cr–1 Mo–0.25 V alloy resulted in the errors tabulated after the commas in Table 5. Study of such comparisons for this and other alloys leads to the conclusion that in general the stresses calculated by parameter extrapolations are in better agreement with *straight-line* extrapolations of isothermal curves than with *curvilinear* extrapolations of the same isothermal curves.

Another conclusion to be drawn from Table 5 is that for the 1 Cr–1 Mo–0.25 V alloy, the best parameter to use depends upon the temperature, and thus this alloy becomes an exception to the general superiority of Manson-Haferd parameter.

Finally, studying Tables 4 and 5 with respect to the value of C to use in the Larson-Miller parameter yields the following conclusions: Table 4 indicates that using the optimum value of C rather than *20* leads to considerably more accurate results as far as extrapolation is concerned. This also proves to be true with the other alloys except 1 Cr–1

TABLE 3 — COMPARISON OF THE DEVIATIONS OF THE THREE PARAMETER METHODS[a]
(Showing How Closely Their Master Curves Reproduce Original Data)

Time Span[b]	Alloy[c]	Larson-Miller[d]	Dorn	Manson-Haferd
0-100 Hr	S-590[e]	0.235, 0.293	0.564	0.174
	S-590[f]	0.278, 0.343	0.646	0.178
	A-286	0.211, 0.211	0.207	0.188
	80A	0.493, 0.612	0.275	0.108
	Cr-Mo-V	0.386, 0.389	0.638	0.280
100-1000 Hr	S-590[e]	0.295, 0.464	0.392	0.250
	S-590[f]	0.351, 0.585	0.481	0.305
	A-286	0.208, 0.208	0.188	0.191
	80A	0.342, 0.464	0.237	0.102
	Cr-Mo-V	0.431, 0.315	0.607	0.243
1000-10,000 Hr	S-590[e]	0.182, 0.235	0.239	0.115
	S-590[f]	0.195, 0.287	0.268	0.123
0-1000 Hr	S-590[e]	0.293, 0.510	0.375	0.260
	S-590[f]	0.351, 0.655	0.430	0.324
	A-286	0.207, 0.207	0.172	0.134
	80A	0.385, 0.530	0.235	0.091
	Cr-Mo-V	0.339, 0.275	0.617	0.274
0-10,000 Hr	S-590[e]	0.131, 0.282	0.282	0.100
	S-590[f]	0.138, 0.348	0.309	0.112

[a] Deviations were calculated statistically by taking the sum of the squares of the actual deviation values, dividing by the number of deviations, and taking the square root of the result $(\sqrt{\Sigma(X_a - X_c)^2/N})$.
[b] Time span of the original data which were used to calculate the particular master curve.
[c] Only long-time original data were used for comparison, as follows: S-590, as indicated; A-286, only data over 1000 hr; 80A, only data over 10,000 hr; Cr-Mo-V, only data of the five longest rupture times.
[d] The first of two values was determined by using the master curve based on the optimum value of C, the second by using the master curve based on $C = 20$.
[e] Original data used for comparison were only the longest rupture times at 1200, 1350 and 1500 F.
[f] Original data used for comparison were only the data over 10,000 hr.

Parameters and Master Curves

Why they are used

Predicting long-time stress-rupture strength is a problem faced daily by design engineers. Such predictions can be fairly accurate if the testing time span is close to the service life. But more often estimates must be made from relatively short-time data. This may be done either by semi-log methods (not discussed in this article) or by first plotting a master curve based on one of several parameter techniques which incorporate time-temperature data into an equation that is a function of stress. Long-time results can usually be read directly from this master curve.

How they are limited

One limitation is that master curves based on different parameter techniques yield contradictory results. A second limitation is that to be complete a master curve has to be calculated from data which includes tests at temperatures above the service temperature. In the case of ferrous alloys, service temperatures are often close to the transformation range and adequate test data are difficult to obtain. Short extrapolations of the master curve are therefore likely to be necessary when predicting longtime results. Here again the various parameter techniques yield contradictory results.

TABLE 4—PERCENTAGE ERROR OF EXTRAPOLATIONS TO 100,000 HOURS
(Compared to Extrapolations of Isothermal Curves)[a]

Master Curve[b]	Larson-Miller		Dorn[c]	Manson-Haferd[c]
	C=17[c]	C=20[c]		
0-100 Hr	+4.3, −6.7	+15.2, − 3.3	+13.0, +3.3	+4.3, −10.0
100-1000 Hr	+6.5, −3.3	+13.0, + 6.7	+13.0, +3.3	+2.2, − 3.3
1000-10,000 Hr	+6.5, −3.3	+10.9, 0	+13.0, −6.7	+2.2, −10.0
0-1000 Hr	+6.5, 0	+15.2, +10.0	+13.0, +3.3	+4.3, − 3.3
0-10,000 Hr	+6.5, −3.3	+13.0, + 3.3	+13.0, −3.3	+2.2, − 6.7

[a]Extrapolation of the isothermal curve of S-590 at 1200 F for an assumed time of 100,000 hr yields a stress of 23,000 psi. Extrapolation of the 1350 F curve to 100,000 hr yields 15,000 psi.
[b]Time span of the original data which were used to calculate the particular master curve.
[c]The first of two values is the percentage error in stress at 1200 F (i.e., error from 23,000 psi); the second value is the percentage error at 1350 F (i.e., error from 15,000 psi).

TABLE 5—PERCENTAGE ERROR OF EXTRAPOLATIONS
(Compared to Two Methods of Extrapolating Isothermal Curves)[a]

Temp, F	Master Curve[b]	Larson-Miller		Dorn	Manson-Haferd
		C = 22	C = 20		
900	0-100 Hr	− 3, +1.7	− 8, −3.4	+11, +17.0	− 6, −1.7
	100-1000 Hr	+ 3, +8.5	+1.6, +7.0	+11, +17.0	− 5, 0
	1000-10,000 Hr	—, —	—, —	—, —	—, —
	0-1000 Hr	0, +5.0	−3, +1.7	+12, +19.0	− 5, 0
	0-10,000 Hr	—, —	—, —	—, —	—, —
1000	0-100 Hr	+29, +67	+13, +46	+32, +71	+ 3, +33
	100-1000 Hr	+34, +75	+23, +58	+32, +71	0, +29
	1000-10,000 Hr	—, —	—, —	—, —	—, —
	0-1000 Hr	+29, +67	+1.6, +31	+32, +71	0, +29
	0-10,000 Hr	—, —	—, —	—, —	—, —
1100	0-100 Hr	+17, +59	−13, +18	+ 3, +41.0	−33, −9.0
	100-1000 Hr	—, —	—, —	—, —	—, —
	1000-10,000 Hr	—, —	—, —	−33, —	—, —
	0-1000 Hr	+10, +54	−10, +13	0, +36.0	—, −9.0
	0-10,000 Hr	—, —	—, —	—, —	—, —

[a]The first of two values is based on *straight-line* extrapolation to 30,000 hr of the indicated isothermal curves for 1 Cr-1 Mo-¼ V alloy steel; the second value is based on *curvilinear* extrapolation of the same curves. The stress readings obtained from these extrapolations are: Straight-line—900 F, 62,000 psi; 1000 F, 31,000 psi; 1100 F, 15,000 psi. Curvilinear—900 F, 59,000 psi;
[c]The first of two values is the percentage error in stress at 1200 F (i.e., error from 23,000 psi); the second value is the percentage error at 1350 F (i.e., error from 15,000 psi).

Mo—0.25 V (Table 5); in this case accuracy is about the same either way for straight-line extrapolation, but $C = 20$ proves to be better than $C = 22$ when matched against curvilinear extrapolation.

Considering minimum time ranges

Most designers undoubtedly limit extrapolations as much as possible. Nevertheless there are reported instances of extrapolated 100,000-hr information based on 5000-hr data. A study of the data obtained for the four alloys discussed in this article shows that the worst of the parameter methods generally gives better results than extrapolations, whether straight-line or curvilinear, over 1½ log cycles or more.

The purpose of plotting master curves for five different time ranges was to try to detect a trend with respect to extrapolative limits. Unfortunately, few trends are detectable within the limits of these calculations. But in using any parameter method, rupture data to at least 1000 hr are desirable, and temperature and stress ranges must be sufficient to determine values of the constants.

This article is based on a paper presented before the annual meeting of The American Society of Mechanical Engineers last fall.

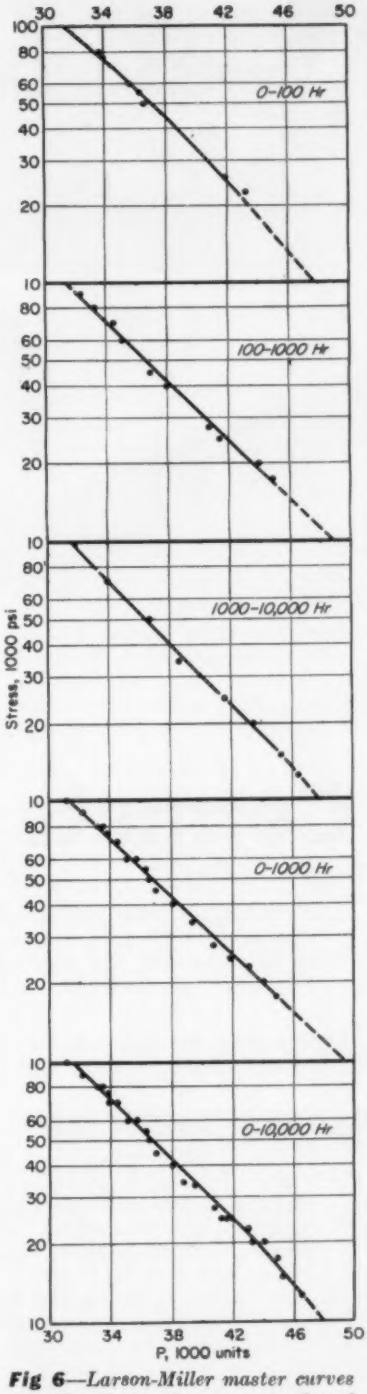
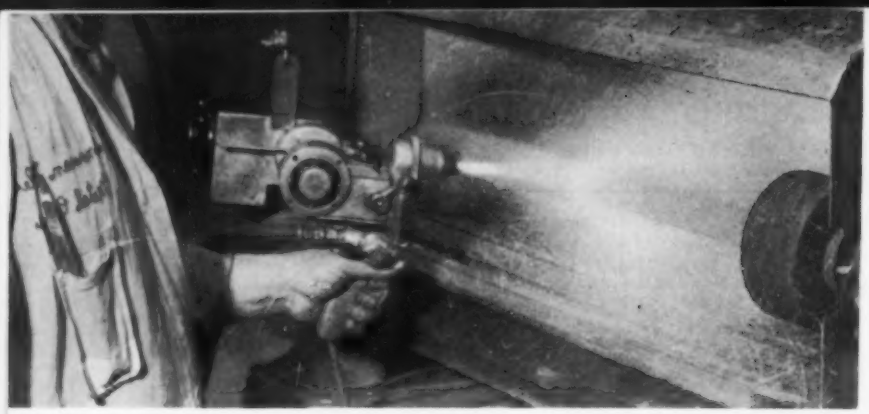
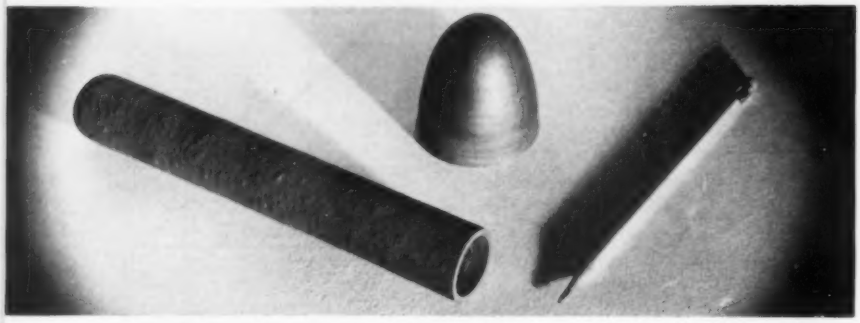


***Fig 6**—Larson-Miller master curves for alloy S-590. Curves were plotted from data of Table 1, using various time spans of data as shown, and the parameter formula: $P = (T + 460)(\log t + 17)$. Similar curves (not shown in this article) were plotted for alloys A-286, Nimonic 80A and 1 Cr–1 Mo–1/4V.*





Flame spraying *cermets with special gun. Parts at bottom are thermocouple protection tube and experimental nose cone.*

Cermets / Two new forms

made possible by a special flame spraying process. Here are the limited facts presently known.

by William H. Herz, *American Electro Metal Div., Firth Sterling, Inc.*

■ Cermets have proved valuable in many high temperature applications because of their high melting points and excellent resistance to oxidation and abrasion. Because of fabrication restrictions, their use to date has been limited to small parts of uncomplicated shape. However, development of a special flame spraying method now permits these useful materials to be produced in the form of coatings, or as fairly large and complex structural parts.

A number of different cermets can be flame sprayed onto many different metals, and structural parts of almost any size can be produced. The cermets that have been successfully flame sprayed so far are:

- Molybdenum disilicide ($MoSi_2$).
- Chromium carbide with or without nickel.
- Chromium-nickel boride (Cr_2NiB_4).
- Tungsten-carbon and tungsten-boron compounds.
- Nickel aluminide (NiAl).
- Molybdenum aluminide ($MoAl_2$).

For spraying purposes, these materials are extruded and sintered into rods ⅛ in. in dia by 16 in. long. A specially designed flame spraying gun (Borocote Metallizer, Metallizing Co. of America) feeds the cermet rods into an oxyacetylene flame. High pressure air then propels the molten particles against the object to be coated.

Coatings:

excellent resistance to abrasion and high temperature oxidation

Each of the cermet coatings that has been developed is distinguished for one or a group of properties that make it valuable. Because of the newness of the coatings, detailed property data is lacking at present. Nevertheless, despite their greater porosity,

How Does Process Compare with Plasma Jet?

Because of the high temperatures that it creates—up to 30,000 F—the plasma jet process (see M/DE, Sept '58, p 162 and Mar '58, p 133) can be used to melt and deposit a wide variety of high temperature materials. However, many materials, such as those described in this article, can be melted and deposited quite satisfactorily with an oxyacetylene flame and air pressure. At the present state of development, the oxyacetylene process is easier to handle and the equipment required is readily available. It is also claimed that the oxyacetylene flame spraying process is generally less expensive than the plasma jet process. However, this advantage may be eliminated when the plasma jet process is more widely used. In general, the plasma jet process produces higher density materials than flame spraying. However, these materials, like flame sprayed materials, must be sintered to develop optimum properties.

cermet coatings can be expected to compare favorably with equivalent solid cermets.

Molybdenum disilicide

Of the new cermet coatings, molybdenum disilicide appears to be the most promising. The material has very good resistance to oxidation at temperatures up to 2900 F, and has reportedly been used to protect molybdenum parts operating at 2700 F for several hours. Molybdenum disilicide has also been successfully sprayed onto graphite, copper and steel. The material tends to be brittle but, depending on the application, this may not be a problem.

Chromium carbide

Chromium carbide coatings, with and without nickel, are noted for their high resistance to abrasion and oxidation. Maximum operating temperature is very roughly the same as for molybdenum disilicide. However, temperature limits can vary widely depending on nickel content, which can run from 5 up to 15%.

Chromium carbide coatings have a density of about 90% and can be readily ground to a smooth finish if desired. The coatings have been experimentally applied to parts such as valve stems, finger pads for screw machines, and turbine blades. The coatings are now being evaluated and they are expected to outperform other protective treatments formerly used.

Chromium-nickel boride

A chromium-nickel boride cermet coating has proved to be well suited for protecting iron and steel against attack by molten aluminum. The coating is easily sprayed and has successfully protected parts such as thermocouple tubes, transfer troughs, fixtures and wire guides against molten aluminum during several hundred hours of immersion. It also provides oxidation resistance to these parts outside of the bath, provided that no fluoride flux has been used in the bath. Because of its good resistance to thermal shock, the coating has also proved useful in protecting rocket combustion chambers and other high temperature parts.

Tungsten-carbon and tungsten-boron

Cermet coatings of either of these two compounds have a density of about 0.53 lb per cu in. (as compared to 0.28 for steel) and are especially useful in increasing weight in restricted places. In aircraft applications, for example, thick coatings can be used for weight balancing in complicated places where it would be difficult to fasten high density metals that are only available as solids.

Aluminide coatings

Two other cermets that have been successfully applied by flame spraying are nickel aluminide and molybdenum aluminide. Nickel aluminide has a melting point of about 3000 F and, outside of its resistance to molten glass, does not appear to have any special properties that make it useful. In general, the same conclusions apply to molybdenum aluminide.

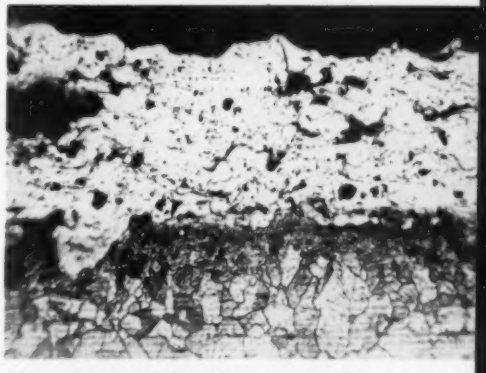
Parts:

larger and more complex high temperature parts

Spray formed cermet parts are made by building up coatings on an expendable pattern. The parts can be built up to almost any size or shape, and when spraying is completed the pattern is removed by chemical or other means. In this way, parts such as large tubes with varying wall thickness, flat radiation shields and large conical shapes can be made out of all of the cermet materials listed above. The relative density of these parts varies from 82 to 90%, depending on the cermet used. If desired, densities as high as 95% can be obtained by a sintering process which is quite similar to that used in powder metallurgy. Sintering is carried out at 2000 to 2500 F and causes the coating to diffuse into, and in some cases alloy with, the base metal.

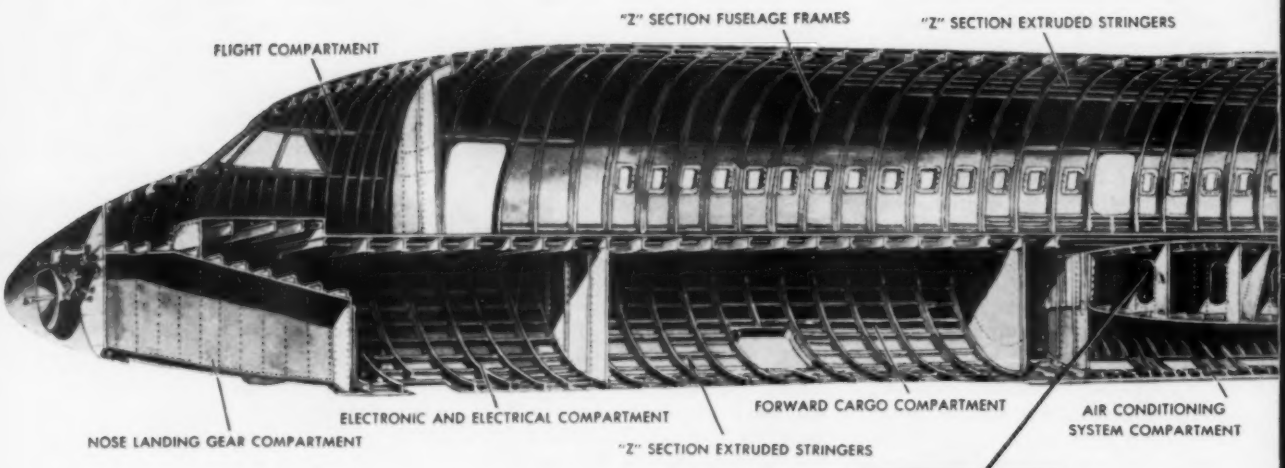
Cermet parts are usually made by conventional powder metallurgy techniques in which the cermet powders are press formed in a die, ejected, and then sintered. The limited size of the dies and presses that are available places a severe restriction on the dimensions and shapes of parts that can be made. The high melting point and excellent oxidation resistance of some cermets are especially desirable for parts such as nose cones, rocket nozzles, and linings for combustion chambers and jet exhausts. Yet these parts are all too large or complicated to be made by ordinary powder metallurgy methods. However, now they can all be made by spray forming. Thus, it is expected that spray forming will be used instead of standard techniques for forming difficult shapes, and will supplement the slip casting method recently developed for producing cermet and refractory hard metal parts.

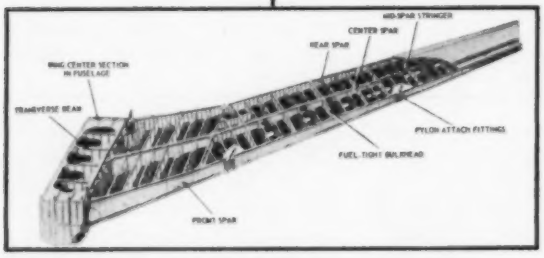
Two typical parts that have been produced by spray forming are shown in the accompanying photograph. The long thermocouple protection tube is spray formed from chromium-nickel boride and is designed to be used in liquid aluminum. The experimental nose cone is also made from the same material; however, depending on the application, it can readily be made from any of the other cermet materials described.



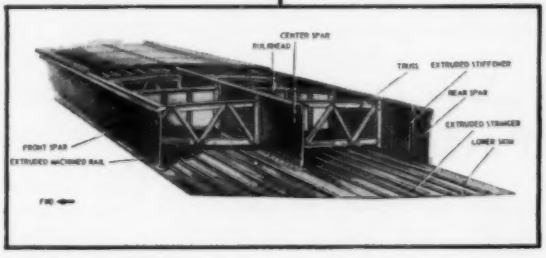
***Chromium carbide** flame sprayed coatings have excellent bond to steel as shown in this photomicrograph, taken after sintering.*

How Lightweight Materials Will Be Used in





Wing structure *has three main spars between root and outer engine. Trailing edges are made of aluminum honeycomb.*



Spars and bulkheads *are assembled with rivets and special adhesive to strengthen joints and make them leakproof.*

1. Aluminum provides safe, efficient structure.

Fuselage and wing design will incorporate many new safety features. Emphasis will be placed on fatigue resistant materials and a structure that remains safe after failure of any single unit.

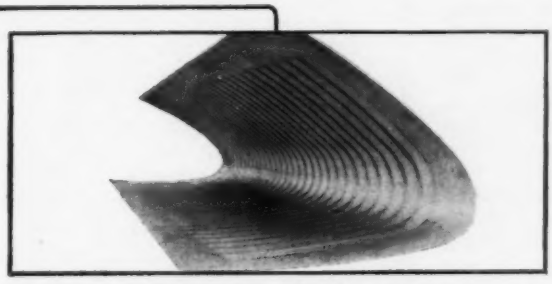
by T. L. Heid, *Structures Group Engineer, Convair, San Diego*

Wing design . . . features tapered skin, honeycomb trailing edges, etched leading edges with integral air passages, and metal-to-metal adhesive bonding between sections.

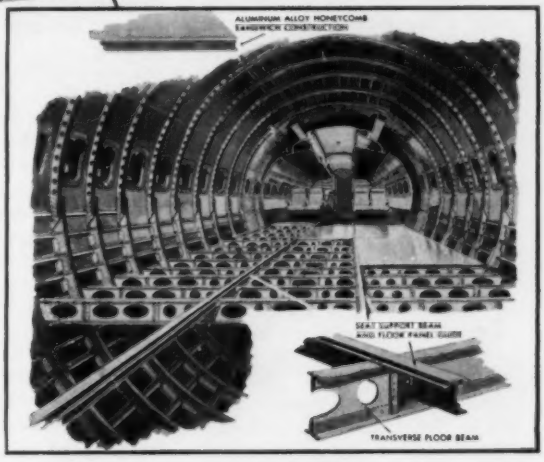
Primary structure—As shown in Fig 1 and 2, the wing spars of the 880 are fabricated from machined rails, extruded stiffeners and roll-tapered webs. They are assembled with rivets and a special bonding adhesive which strengthens the joints, protects the bearing surfaces, and makes the seams liquid-tight. Except for the upper front spar rail, the upper stringers and spar caps are made from 7178-T6 aluminum alloy. A 2024-T4 aluminum alloy was selected for the upper front spar rail because it is subjected only to relatively low stresses, and the ductility of the material affords good resistance to forward-acting fuel loads in the integral tanks in the event of sudden deceleration. The more ductile 2024 alloy is also used for the lower spar rails and stringers.

An epoxy adhesive (Scotchweld) is used throughout the wing box structure and the integral fuel

the Convair 880 Jet



Leading edges *of wings contain etched-in channels which circulate hot air from engine compressors to prevent icing.*



Cabin floor *consists of aluminum honeycomb sandwich supported by transverse floor beams at each fuselage frame.*

tanks. This metal-to-metal adhesive seals all seams and joints in the fuel tank area. It also contributes materially to the strength of riveted joints and increases resistance to fatigue and corrosion. All of the parts that make up the fuel tanks are sprayed with a Scotchweld primer and cured at 150 F prior to assembly. After assembly, the complete wing is placed in a large oven and held at a temperature of 320 F for 1 hr. This final curing operation literally "welds" the entire fuel tank structure into a solid unit that is leakproof and maintenance-free.

Skin—The upper and lower wing surfaces are formed from tapered aluminum alloy sheets whose thickness decreases spanwise from the wing break to the tip. This construction provides maximum structural strength with minimum weight. The skin surfaces are supported by extruded Z-stringers which are attached to the ribs and bulkheads.

High compression strength 7075 alloy is used for the upper skin surface where structural strength is the most important factor. The more ductile 2024 alloy is used for the lower skin surface where fatigue is the primary consideration.

Trailing and leading edges—Aluminum honeycomb sections are used for the trailing edges of wings, ailerons, flaps and spoilers. This type of construction provides a strong, lightweight structure with good resistance to vibration.

A very interesting type of construction is used for the wing leading edge to prevent ice formation. As shown in Fig 3, the leading edge is formed from a double skin which contains integral air passages through which hot air can be circulated from the engine compressors. These passages are formed by etching chordwise channels in the back surface of the heavy-gage outer skin. The inner and outer surfaces are then riveted together and fastened to the nose ribs along the lands which separate the channels. The design provides an excellent heat ex-

changer, and thermal efficiencies as high as 90% have been obtained.

Fuselage design . . .
features a honeycomb sandwich floor and a skin of variable thickness.

Primary structure—Most of the fuselage frames are fabricated from stretch-formed 7075 aluminum alloy Z-sections, a typical frame being 3⅛ in. deep with a metal thickness of 0.05 in. Typical stringers are 0.05-in. extruded aluminum alloy Z-sections, ⅞ in. deep. A 2024 aluminum alloy is used for the stringers along the floor line, and a 7075 alloy is used for the remaining stringers.

Spacing of the stringers varies from 6 to 9 in. As shown in Fig 4, stringers are omitted from the cabin walls where the heavier gage skin provides the necessary strength. An area along the top of the fuselage varying from 15 to 40 in. on each side of the center line is reinforced with stringers, the wider installation being over the wing.

The cabin floor consists of an aluminum alloy honeycomb sandwich which is supported by transverse floor beams at each fuselage frame. Elimination of vertical supports for the floor beams provides a more resilient belly structure in case of a wheels-up landing. A heavy extruded keel member, located at the plane of symmetry on the fuselage bottom, insures structural stability in the region where the normal fuselage structure is interrupted by the wheel wells and the wing center section.

As shown in the cutaway view of the fuselage, the aft pressure bulkhead is located forward of the movable horizontal stabilizer. This arrangement eliminates the necessity for sealing the fuselage-stabilizer joint.

Skin—Because of its superior resistance to crack propagation, a 2024 aluminum alloy is used for the fuselage skin. Skin gage varies from 0.06 to 0.10 in., with the heavier gages being used above the cabin floor line where the windows and most of the openings are located. The extra heavy skin provides additional crack resistance without increasing weight, and the noise-damping effect of the thicker skin permits a reduction in the amount of soundproofing material needed. Actually, overall weight is reduced, since the heavier skin eliminates the need for stringers over a considerable portion of the fuselage surface.

Windows—Windows of the 880 are about 9 x 12½ in. in size and are located two to a seat, or four for each cabin bay. The frames are single-piece aluminum alloy forgings and are supported by the skin without additional reinforcing. The window itself is made up of two acrylic sheets (Plexiglas 55), separated but mounted as a single outer unit, plus an inner window pane mounted in rubber. Structural load can be absorbed by either of the two outer panels.

Structure Is Not Jeopardized if a Single Unit Fails

Probably the most distinguishing structural feature of the 880 is the fail-safe, fatigue resistant construction used for both the wing and the fuselage. This type of construction is based on the concept of "coexistence" of all structural members. That is, structural integrity is not jeopardized if any single unit fails.

Design of structure

Wing—The primary structure of the 880 wing is a box beam consisting of spars, bulkheads, stringers and plates. As shown in the cutaway view, Fig 1, a three-spar arrangement is used from the fuselage to the outboard engine. Use of the center spar provides a more even distribution of the wing loads and provides intermediate support for the wing ribs and bulkheads. The wing ribs follow conventional truss design, and the bulkheads are web-type with reinforcing stiffeners. Only two spars are used beyond the outer engine. The leading and trailing edges in this area are designed to provide a fail-safe structure.

The wing center section beneath the fuselage has four transverse beams between the front and rear spars. Each of these beams is attached to a fuselage frame. Failure of any one of these beams or attaching frame will not jeopardize the strength of the structure.

A short auxiliary spar, located aft of the rear spar between the butt and first ribs, supports the main landing gear. This spar is supported jointly by the fuselage and the wing structure and is designed to allow the landing gear to break free of the wing without rupturing the fuel tanks in the event of a crash landing.

Fuselage—The most prominent features of the 880 fuselage design are shown in the cutaway view on pp 100 and 101. In general, the same fail-safe features that are applied in the wing design are also applied in the fuselage design. These features have been evaluated by repeated load testing with particular emphasis on determining the fatigue resistance of the various subsections.

Testing of structure

It is estimated that skin stresses in the 880 fuselage will be low enough to preclude fatigue cracks during the normal life of the airplane. Nonetheless, an extensive test program was conducted to demonstrate that ruptures would not produce a major failure prior to their detection by inspection.

A series of fail-safe tests were conducted in which various members were cut and loads applied to demonstrate that the section being tested retained its integrity. Emphasis was placed on very low rates of crack growth. In no case did explosive failure occur in a fuselage frame or panel.

In another test a steel javelin was dropped through the fuselage skin while it was under pressure. Although a large cut was made in the skin, there was no evidence of added failure.

2. Reinforced plastics provide light weight, good appearance.

Over 1500 lb of reinforced plastics will be used in the Convair 880 jet, mostly for furnishings, electrical and air conditioning equipment, and thermal insulation. Here is the story on how and why plastics are used.

by H. H. Rosenbaum, *Design Specialist, Convair, San Diego*

Selection of materials for a new airplane is often based on experience gained with the materials in previous airplane designs. Some materials, such as the aluminum alloys and steels, are regarded as standard and no unusual studies are required to justify their selection. However, other materials such as reinforced plastics require thorough and costly evaluation if they are specified for components for which they have not previously been used.

The decision to use reinforced plastics for the Convair 880 was made only after careful comparison with other materials. Careful attention was given to thousands of parts to see if weight or cost could be reduced by using a reinforced plastic. A reinforced plastic was selected for some parts primarily because of its light weight, even though the part could be produced with other less expensive materials and methods. However, in most cases where a reinforced plastic was used it provided both a lighter and less expensive part than could be produced in aluminum. Aside from weight and cost considerations, a reinforced plastic was often selected because of its electrical or thermal properties.

Furnishings . . .
in certain cabin areas to allow tural, and primary emphasis in their design is placed on appearance and utility.

Overhead panels and racks—The overhead panels (first photo) in the 880 are of a unique sandwich construction consisting of a single layer of lino weave glass fiber cloth and epoxy resin cemented to each side of a honeycomb core. The visible face of each panel is covered with a decorative vinyl fabric. This fabric is perforated in certain cabin areas to allow sound to pass through the panel and be absorbed by a hidden layer of insulation. In other areas the perforations are omitted to prevent sound from being transmitted into the cabin from the outside.

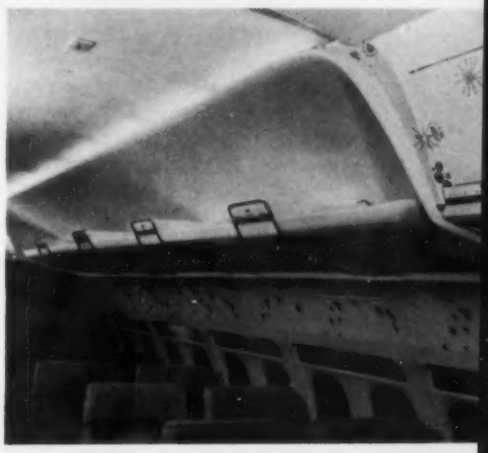
The hat racks and hand rail extensions over the seats are molded from a polyester-glass fabric laminate. This material was selected because it could be easily formed to a difficult contour. A polyester-glass laminate is also used for the canopies (nicknamed "canoes") above the hat racks.

Window frames — As shown below, a large one-piece glass-reinforced plastics frame is used to enclose the double windows. Because of the intricate shape and large quantities involved, these frames are molded in matched metal dies. The surface finish of the frames is enhanced by using a veil mat and by painting.

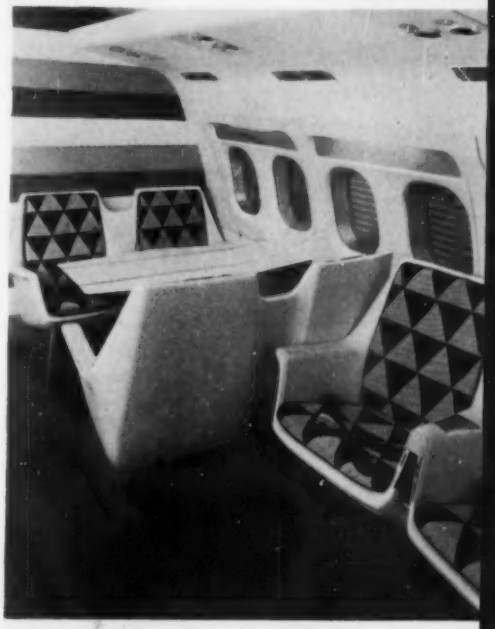
Wainscotting—The cabin trim, or wainscotting, shown beneath the windows is made from a glass fiber laminate backed with a flexible vinyl foam. Since these panels are located at the floor level and take a lot of abuse they are covered with a harmonious vinyl-coated fabric.

Club seats—A unique feature of the 880 is the club compartment which contains seating accommodations for 12 passengers. Shown in Fig 6, these seats are made of glass-reinforced polyester plastic and consist of top and bottom shells which are separated and bonded to a foamed-in-place plastics core.

Vertical partitions—All vertical partitions (see photo on p 104) are of sandwich construction and contain an aluminum or paper honeycomb core. Each side is



Hat rack *and overhead canopy are molded from polyester glass fabric laminate and faced with decorative vinyl fabric.*

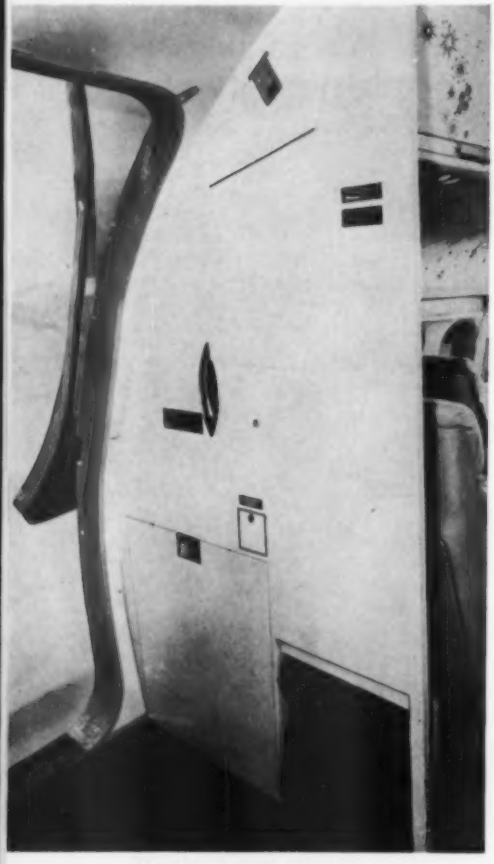


Windows *are enclosed by large one-piece glass fiber-reinforced frame. Club seats consist of top and bottom reinforced plastics shells separated by a plastic foam core.*

faced with a glass fiber-phenolic resin laminate.

Flight deck parts—A considerable number of parts on the flight deck of the 880 are made of reinforced plastics. The most prominent parts are the instrument and equipment consoles located next to the pilots. These consoles have a complex contour and are bag molded from a polyester resin and glass fabric. Cost and weight considerations dictated the use of plastics laminates for these parts. For the same reasons the material was also selected for the side and overhead trim panels in the crew compartment and various storage bins and boxes on the flight deck.

Electrical equipment . . . and communications equipment represent the second largest use of reinforced plastics in the 880.



***Vertical partitions** are made with honeycomb core and are faced with a glass fiber-phenolic resin sheet.*

Radome—The radar equipment is housed by a thin-wall plastics laminate radome which forms the nose of the fuselage. This radome is about 5 ft in dia by 4 ft long and is molded from a glass fiber-epoxy resin laminate to a thickness of about 0.08 in. The epoxy resin was selected because of its high resistance to rain erosion.

Antennas—A glass fiber-epoxy resin laminate is also used for a 25-ft long antenna fairing which runs along the top exterior side of the fuselage. This fairing houses four flush antennas and is made in three parts.

The vertical fin of the airplane contains two flush VHF antennas consisting of a glass fiber sandwich with a metal screen embedded in the outer surface. An epoxy resin is used for the skin and a phenolic-glass fiber honeycomb is used for the core. The fin also contains a 10-in. wide glass fiber-epoxy laminate section which electrically isolates the fin tip from the rest of the fin. This section also extends through the rudder. Thus, the laminate is not only an electrical component but is also part of the primary structure of the fin and rudder.

Five additional antennas, which make up the aircraft communications system, are either embedded in, or housed by, epoxy laminates.

Junction boxes—All major electrical junction boxes are made from glass fiber impregnated with a special polyester resin modified to be fire resistant and self-extinguishing. This reinforced plastic was selected because of its good electrical properties, ease of molding and low tooling costs.

The boxes vary in size from 2 x 7 x 7 in. up to 6 x 30 x 30 in. In order to keep cost and weight down, wall section thicknesses are varied. Thickness is increased where the box is attached to the aircraft structure or where equipment is mounted on the box. Local increases in thickness or molded beads are also provided in other areas where additional stiffness is required.

Covers—A number of plastics laminates shrouds or covers are used over electrical equipment located in various parts of the aircraft. These shrouds are generally flat laminate sheets which are riveted or bolted to metal frames. Some panels require molded-in beads and flanges to increase rigidity over large unsupported areas. Plastics were chosen for these parts because of their light weight and resistance to hydraulic fluids such as Skydrol 500.

Air conditioning components . . . make major use of reinforced plastics. Glass cloth-phenolic laminates are used for about 150 ft of ducting, plus 44 air slots and many transition sections. The phenolic laminates were selected for their toughness and long life, light weight, fire resistance, ease of handling and moderate cost.

In most cases the more complicated duct shapes could be made more cheaply from plastics than from metal because of the simpler tooling and lower labor costs for the quantities required. However, it was found that the more simple shapes could be made more advantageously from metal.

Thermal insulation . . . is especially important in order to prevent overloading of the heating system in the 880, since this aircraft has been designed to operate at altitudes where temperatures are as low as —65 F.

In addition to the usual glass fiber and foam insulations, wide use is made of reinforced plastics that combine low heat conductivity with good mechanical properties. Reinforced plastics are used as insulating and structural strips and hangers between interior panels and the basic structural members of the airplane. The same type of construction is used to suspend equipment shelves and racks from the structure.

Other uses . . . of reinforced plastics include:

1. The cargo compartment, which is lined with reinforced plastics panels.

2. A protective shroud for equipment that might be exposed to leaking hydraulic fluids.

3. Scuff plates, rubbing strips, fairleads and spacers.

Culled from over 100 papers given at the recent annual meeting of the Society of Plastics Engineers, here are the new developments on . . .

What's New in Plastics for Engineering Uses

- *New types of plastics*
- *Glass microballoons for foams*
- *Properties of polyethylene blends*
- *More data on ablation*

By Malcolm W. Riley, *Associate Editor, Materials in Design Engineering*

CTL, Inc.

Good ablation characteristics *of reinforced phenyl-silane resins make them suitable for such uses as nose cones and missile blast deflectors.*

■ For those interested in practical design information, developments in six areas highlighted the recent SPE meeting:

Reverse polyesters

Reverse polyesters — so-called because the basic resin-forming reactions are the "reverse" of those used in producing conventional polyesters—are aimed at meeting the need for a thermosetting material that can be molded at low pressures (10-100 psi) by conventional, economical, high speed molding techniques, such as compression and transfer molding. *Muskat's* discussion was concerned with Elkin Chemical's reverse polyesters known as Elkinite Resins. They can be used as molding compounds and also for coatings, adhesives and impregnants.

These molding compounds are available either unreinforced or reinforced. The unreinforced compounds are designed for compression molding at pressures of 50-100 psi, producing either clear moldings with good overall properties, or filled and/or pigmented moldings with modified properties or colors.

Glass-reinforced compounds require molding pressures of only 10-100 psi. Compounds are reported to readily wet glass reinforcements, and provide good mechanical strengths in the cured condition.

Both reinforced and unreinforced molding compounds still have some handling difficulties that must be overcome.

Other uses—Reverse polyesters can also be formulated for preimpregnating fibrous reinforcements. After suitable treatment, such "prepregs" can be laminated and molded by conventional techniques.

New fire resistant epoxies

A new chlorinated epoxy resin (about 30% chlorine content) is designed primarily for castings, pottings or laminates, where flame resistance is required. According to *Cooke* of Jones-Dabney, cast samples formulated for an optimum balance of mechanical and electrical properties burn for only 2 sec when ignited on one end and held either horizontally or vertically. This value compares with a burning time for conventional epoxy castings of about 50 sec when held horizontal to the flame, and continued burning when held vertical.

Mechanical strengths of both castings and laminates made of the new resin are somewhat lower than those obtainable with other epoxies. Typical values for castings include: ultimate flexural strength, 13,900 psi; Izod impact strength, 0.27 ft-lb per in. notch; Rockwell hardness, M106. Heat distortion temperature at 264 psi stress is about 270 F.

Electrical properties of these castings are comparable to those of conventional epoxies at temperatures up to about 300 F. Typical dielectric characteristics: volume resistivity, 1 x 10^{16} ohm-cm; dissipation factor at 1000 cycles, 0.0006; dielectric constant at 1000 cycles, 3.61; dielectric strength, 315 v per mil.

Improved grades of ABS plastics

Among the more recent grades of ABS (acrylonitrile-butadiene-styrene) resins are low temperature impact grades, and high tensile strength, heat resistant grades.

Low temperature impact—Marbon Chemical's *Irvin* reports that grades of ABS materials now available provide minimum Izod impact values at –40 F of 4 ft-lb per in. notch (room temperature value: 10 ft-lb per in. notch). In these grades, types are available for extrusion or calendering, or for mixing with other ABS materials to improve their low temperature toughness. Other types are particularly designed for extruded pipe or for sheet forming applications where deep draws require good tensile strength at forming temperatures.

Strength plus heat resistance—Recent ABS grades provide a combination of higher tensile

strengths (about 7000 psi, compared with usual values of about 4500-5500 psi) coupled with higher heat resistance (ASTM heat distortion values: 264 psi stress—208 F, compared with usual value of about 195 F; 66 psi stress—220 F, compared with about 212 F).

Heat distortion measurements have limited utility in evaluating heat resistance. *Irvin* presents comparative curves showing the ABS heat resistant grade's flexural modulus of about 400,000 psi to be little affected by exposure to temperatures up to 140 F. Also, exposure of unstressed samples to 212 F dry heat for 48 hr results in very little dimensional change.

TABLE 1—TYPICAL PROPERTIES OF SYNTACTIC FOAMS
(Glass Microballoons and Various Resin Binders)

Binder →	Epoxy		Cross-Linked Polystyrene	Silicone
	Two Component, RT Cured	One Component		
Density, lb/cu ft	20	23	32	25
Dielectric Constant (10^9-10^{10} cycles)	1.45	1.55	1.67	1.6
Dissipation Factor (10^9-10^{10} cycles)	0.01	0.01	0.001	0.002
Compressive Strength, psi	1010	1500	5000	750
Operating Temp Range, F	−70 to +300	−70 to +500	−70 to +350	−70 to +800

Source: *Cuming.*

Glass microballoons for foams

In addition to the original phenolic and urea microballoons previously used in syntactic foams, glass microballoons appear promising, particularly for electrical applications. The microballoons can be used with a variety of binder resins.

According to *Cuming* of Emerson & Cuming, glass microballoons range in diameter from 30-300 μ (average is about 60), and have a bulk density of about 14 lb per cu ft. Heat resistance depends on the type of glass used; maximum service temperature may be as high as 2000 F.

Binder resins which have been successfully used include polyesters, epoxies, phenolics, silicones and crosslinked polystyrenes. Properties of several such syntactic foams are given in Table 1. Flexible foams can be formulated by using vinyl plastisols as binders.

The microballoons can also be used with inorganic binders, such as sodium silicate, colloidal silica and aluminum phosphate, for high temperature cellular structures.

Polyethylene blend properties

Since the development of Type III (higher density) polyethylenes, the question of what properties can be obtained by blending resins of different densities has been often asked. The potential economies in inventory reductions through use of blends are obvious.

Data on such blends presented by *Wolheim* of W. R. Grace should be considered to be primarily qualitative, since he emphasizes that differences in equipment and techniques from shop to shop will result in substantial differences in properties of blends produced.

In developing the data, various Type I (lower density) resins with densities ranging from 0.913 to 0.919 gm per cu cm, and melt indexes ranging from 2.0 to 22 gm per 10 min were used. These were mechanically blended with a Type III material of 0.961-gm-per-cu-cm density and 5.4-gm-per-10 min melt index.

Wolheim's data make it clear that properties of blends of Type III and Type I polyethylenes are not necessarily the same as those of a single resin whose density would correspond with the average density of the blend.

The curve in Fig 1 shows variation of stiffness (ASTM D747) with the amount of Type I resin in the blends. Fig 2 shows the effect on average measured density of blends. Since these were mechanical blends, densities also varied within each sample.

Results of boilability tests indicate that for parts used in boiling water, blends must consist of at least 60% of the Type III material to be free from distortion; 50:50 blends appear to be borderline. Tests consisted of immersing tapered bowls molded with blends of 0.921 and 0.961-gm-per-cu-cm density materials in boiling water for 30 min and inspecting for distortion.

Results of Izod impact strength tests for blends were highly erratic. However, blends containing about 60% or more Type III material produced the most consistent impact strength values (0.83-1.13 ft-lb per in. notch for 60:40 blends).

Reinforced plastics for ultra-high temperatures

The discussions of reinforced plastics for ultra-high temperature uses were notable for the limitations which had obviously been put on the speakers by security requirements.

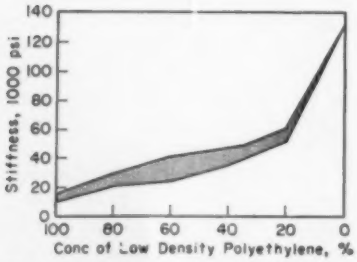


***Fig 1**—Stiffness vs Type I polyethylene content in mechanical blends. Shaded area indicates range obtained using different Type I resins.*

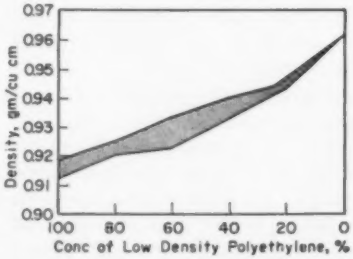


***Fig 2**—Average density vs Type I polyethylene content in mechanical blends.*

TABLE 2—RANGE OF ABLATION ENVIRONMENTS

Class ↓	Temperature, F	Pressure, psi	Radiation Intensity	Exposure Time, hr	Gas Composition	Particles in Gas
Aircraft (aerodynamic surfaces and jet intakes)	212-1850	1.5-150	Negligible	1000-10,000	O_2, N_2	Rain, snow, dust
Rocket Motors (inner surfaces)	3600-5400	1000-3000	Extreme	0.0003-0.03	CO, H_2O, N_2, etc.	Unburnt propellant, ablation products
Re-Entry Bodies (aerodynamic surfaces)	5400-12,600	0-500	Moderate	0.008-0.016	O_2, N_2	Rain, snow, dust
Ordnance (ammunition parts and gun barrels)	3600-5400	20,000-50,000	Extreme	5×10^{-6}	CO, N_2, H_2O, etc.	Unburnt propellant, ablation products

Source: *Perry* and *Silver*.

The general behavior of reinforced plastics under conditions of ablation was neatly summarized by *Perry* and his colleagues of Naval Ordnance Lab. (Two other papers by the same authors also summarized theory and experimental work in studying effects of high velocity hot gases on reinforced plastics.)

Ablation mechanism—The mechanism of ablation involves both thermal and mechanical effects, as follows:

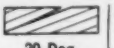
Thermal effects may include any or all of the following: 1) *spalling*, or the cracking or flaking away of expanded material at temperatures below the material's melting point, 2) *sloughing*, or the separation of thermally softened or weakened pieces under stresses caused by wind or acceleration, 3) *sublimation*, or the loss of material thermally transformed directly from the solid to the vapor phase, 4) *run-off* of melted material under wind or acceleration stresses, 5) *evaporation*, or loss of melted material from the liquid to the vapor phase, 6) *pyrolysis*, or loss of gaseous, liquid or solid products of thermal degradation, and 7) *combustion*, i.e., sublimation, evaporation or pyrolysis accompanied by oxidation.

Mechanical effects of ablation may include: 1) *impact erosion* due to local impact of particles or droplets in the gas stream, and 2) *shearing*, or loss of material in solid form due to fracture caused by wind shear stresses.

Table 2 summarizes the usual range of ablation environments.

Design compromises—The compromises necessary in designing reinforced plastics materials for ablation conditions were indicated by *Warnken*, of CTL, Inc., who outlined the effects of lamination direction on ablation behavior. Table 3 indicates how four different lamination configurations are affected by high temperature, high velocity gas flow. The sketches show qualitatively the effects of such environments on parallel laminations, end-grained laminations, 20-deg shingled laminations and random laminations.

TABLE 3—EFFECT OF LAMINATE DIRECTION ON ABLATION CHARACTERISTICS[a]

	Direction of gas flow →			
				
Laminate Direction →	Parallel	End-Grained	20-Deg Shingled	Random
Coef of Ther Exp, 10^{-6}/°F	6.26	25.9	9.91	8.0
Ablation Rate				
High Temp	Good	Excellent	Excellent	Fair
Moderate Temp	Poor	Excellent	Excellent	Good
Surface After Ablation	Rough	Smooth	Smooth	Smooth
Emissivity	0.85	0.85	0.85	0.85
Ther Cond, Btu/hr/sq ft/°F/in.	2.0	6.0	2.9	2.0
Ten Str, psi				
Room Temp	23,200	1500	4500	6000
500 F	21,000	750	3100	2900
Flex Str, psi				
Room Temp	49,100	5100	7300	15,000
500 F	26,700	2600	5500	9000
Flex Mod, 10^6 psi				
Room Temp	2.3	0.7	1.12	—
500 F	1.83	<0.1	0.65	—
Columnar Compr, psi				
Room Temp	37,200	60,000	7700	12,000
500 F	16,500	35,400	5700	5200

[a]Property data are for 379X phenyl-silane resin reinforced with Refrasil, 96% silica glass.
Source: *Warnken*.

Values in the table show typical characteristics of structures made in each of these types of laminated configurations. The data given in the table are for a phenyl-silane resin reinforced with 96% silica glass fiber. As can be seen, the end-grained and shingled grain laminates have the best ablation characteristics, but they also have the highest thermal conductivity and expansion, and relatively low mechanical strengths.

References

The information in this article is based on material presented in the following papers at the 15th Annual Technical Conference of the Society of Plastics Engineers, Inc., Jan '59, New York City:

Cooke, Jr., H. G., "A New Chlorinated Epoxy Resin."

Cuming, W. R., Alford, H. E., Veatch, F., "Glass Microballoon Spheres."

Irvin, H. H., "New Developments in ABS Polymers."

Muskat, I. E., "Reverse Polyesters."

Perry, H. A., Silver, I., Anderson, H. C., Mihalow, F. A., "Behavior of Reinforced Plastics Surfaces in Contact with Hot Gases."

Warnken, E. P., "Designing Reinforced Plastic Systems for Ultra High Temperature Use."

Wolheim, J. B., "Dry Tumbled Blends of High Density and Low Density Polyethylene."

Variety of webbings *used in military equipment is shown in this U.S. Navy full pressure flying suit.*

Nylon barrier webbings *possess ideal combination of strength and elasticity to check speeding aircraft without damage.*

Webbing Materials

Three types offer high strength + elasticity flexibility

by Gladys Hargreaves, *Aeronautical Materials Laboratory, Naval Air Materials Center*

Why New Webbings Were Developed

The webbing materials available to the designer today are far superior to earlier materials.

In the early days of the airplane when speeds were low and flights were short, parachute harnesses were made from a high grade linen webbing. This webbing had a breaking strength of less than 3000 lb and was stiff and uncomfortable to wear.

With the advent of faster aircraft with longer cruising ranges, designers demanded a stronger webbing to withstand the higher impact loads of parachute openings, and a more flexible webbing that would reduce pilot discomfort and fatigue. These requirements led to the development of improved linen webbings which were in turn replaced during World War II by specially treated cotton webbings with nylon filling. Rib-weave nylon and Dacron webbings were later developed for parachute harnesses and other applications.

The early nylon materials had a tendency to fuzz and lose their strength when used with quick-fit parachute hardware. However, this problem was licked by coating the webbing fibers.

■ Webbings are widely used in military equipment because of their versatility. Although the strength of webbings is important in many applications, it is not always the determining selection factor. For example, a high degree of flexibility may be needed, particularly in the case of harnesses that must be comfortable for long periods of time. Similarly, a webbing material may be required to have a high degree of elasticity, as in the case of aircraft crash barriers. At the other design extreme, a webbing material may be required with minimum elasticity, as in the case of aircraft seat belts.

A number of webbing materials have been developed to meet various operating requirements. The most common materials in use today are nylon, cotton and Dacron. Webbings of these materials consist of narrow woven fabrics weighing at least 15 oz per sq yd. These webbings differ from tapes, which usually weigh less than 15 oz per sq yd. Most of the webbings now in use are available in unfinished form, with a resin finish, or impregnated with latex (see table on p 109).

Cotton

Despite the inroads made by the synthetic fibers, cotton still has many advantages as a webbing material. Some of the applications where cotton webbings are now being used to advantage are headbands in aviation helmets, parts of parachute harnesses, suspenders for winter flying suits, and cargo drop kits.

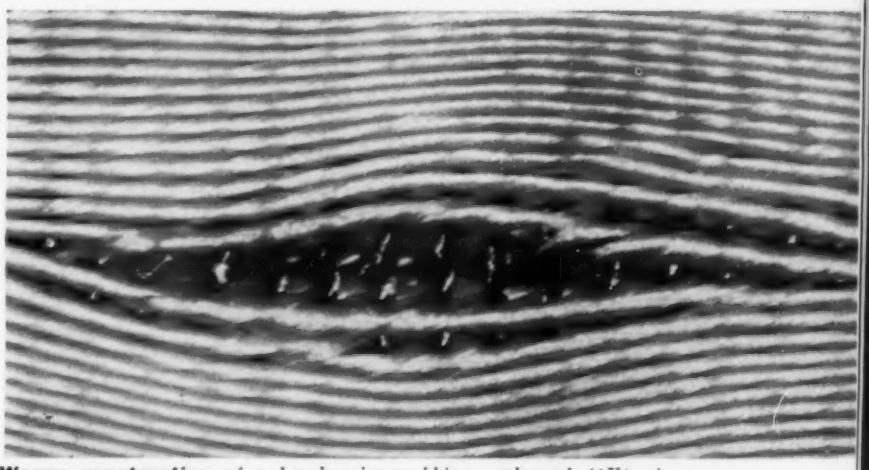
Dried cotton fibers are composed of 95% pure cellulose and 5% impurities. Fibers vary in length from ½ to 2½ in. and have high tensile strengths—from 40,000 to 125,000 psi. The strength of cotton fabrics largely depends on fiber length and the friction and interweaving of the fibers. Thus, the strongest cotton fabrics come from the long fibers which have more friction area than the short fibers.

Cotton fibers are quite durable and have a higher wet than dry

strength under normal conditions. They are not affected by heat up to 248 F. At higher temperatures cotton begins to yellow until at 285 F it turns brown and shows signs of degradation. The material is also extremely sensitive to oxidizing agents and acids, and can even be affected by weak mineral acids under some conditions.

PROPERTIES OF WEBBING MATERIALS

Material ↓	Width, in.	Finishes Available	Breaking Strength, lb
Cotton	¼-10	Mildew and/or water repellant	25-2500
Cotton (elastic)	½-1½	Mildew and/or water repellant	—
Cotton-Nylon	9/16-3	Mildew and/or water repellant	350-5200
Nylon	½-5	Latex or resin	50-50,000
Dacron	1-2	Latex	3400-8200



***Weave construction** of nylon barrier webbing—enlarged (2X) view.*

Nylon

Nylon is probably the most popular webbing material in use today because of its high strength and ability to absorb impact energy. Millions of yards of 10,000-lb "barrier" webbing are used each year in aircraft arresting systems, and for barricades on aircraft carriers (see photo) and emergency airport landing strips. Nylon webbings are also widely used in parachutes and parapack and life raft equipment.

The principal advantages of nylon yarn webbing are high strength and elasticity. The material loses some strength when wet and usually swells slightly and increases in length. After being held in tension for several days the material creeps back to its original length very slowly, complete recovery sometimes taking almost two weeks.

Sunlight has a tendering and weakening effect on nylon. In general, bright yarns are more resistant than dull yarns. A 10,000-lb nylon webbing normally has a breaking strength of 10,100 to 11,000 lb; however, these values can be cut in half after exposure to strong sunlight. A good deal of research has been done on this problem and it has been found that a protective resin or latex coating, or dyeing with dark colors, enables nylon to retain 75% of its original strength after sunlight degradation. Reports also show that a modified nylon known as type 330 will retain 90% or better of its original strength after 100 hr of weatherometer testing.

Nylon will not support combustion and is heat stable up to 248 F, at which point it softens, loses its strength, and turns yellow. In certain weave patterns the material has excellent abrasion resistance. Nylon has fair resistance to dilute acids and generally good resistance to alkalis. It is not soluble in organic solvents with the exception of boiling benzyl alcohol, hot solutions of zinc chloride in methanol, phenolic compounds, and calcium chloride in methanol. Concentrated inorganic acids will deteriorate nylon, as will concentrated formic and oxalic acids. Most bleaches have a tendering effect on nylon. The material is completely resistant to bacteria and fungi, and is very little affected by aging at normal temperatures.

Dacron

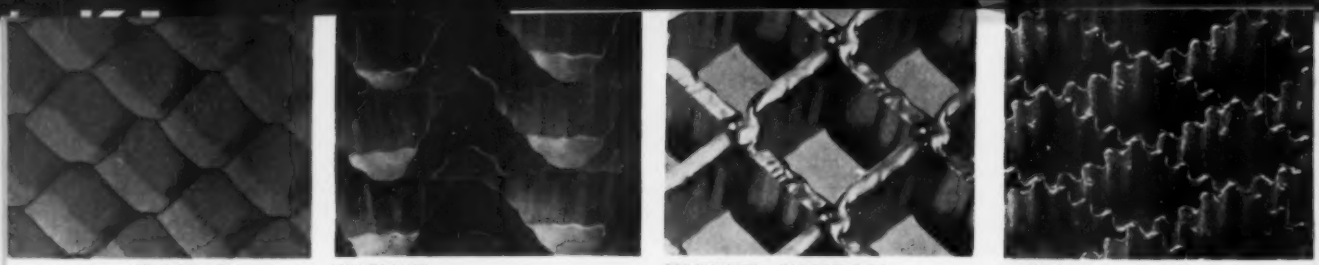
Dacron polyester webbings are comparatively new. However, because of their controllable elongation they have within a short time established their importance in safety harnesses, parachutes and ejection seats.

Webbings made from polyester fibers are extremely tough, have excellent elastic recovery, and are resistant to microbiological attack, bleaches and most organic solvents. The webbings also have good dimensional stability either wet or dry, are resistant to stretching, and have good flex life.

Polyester fibers begin to soften at 450 F and melt at 480 F. Preshrunk yarn has an inverse temperature-length relationship—length decreases slightly with increasing temperature, and increases slightly with decreasing temperature. The material has been exposed to 300 F for long periods with no signs of color change or degradation.

Polyester fibers are attacked by concentrated sulfuric acid, but have good to excellent resistance to other acids. They have good resistance to weak alkalis, but only moderate resistance to strong bases at room temperature, and poor resistance to weak alkalis at high temperatures. Their resistance to oxidizing agents and common bleaches is excellent.

Editor's note: For further property data on the materials discussed in this article see Manual No. 123 on "Industrial Textile Fibers," MATERIALS & METHODS, Dec '55, p 119.



Typical honeycomb cell configurations. *The square cell is the best core type for general use. The corrugated square cell (nine node) and the multiwave structure were developed for curved surfaces which require greater flexibility, but are more difficult to braze because they tend to relax at the brazing temperature. Stresskin is a flanged rigid-tube construction which provides a greater faying area for brazing.*

Brazed Steel Honeycomb Structures for 800 F

Last month Solar Aircraft's Floyd Rechlin discussed six basic rules for designing with brazed honeycomb sandwich. This article emphasizes:

- *Selecting materials—core and face materials, brazing alloys*
- *Properties of honeycomb structures*

by Charles F. Burrows,
Materials Group Engineer, Martin Co.

TABLE 1—FERROUS ALLOYS SUITABLE FOR HONEYCOMB CONSTRUCTION

Alloy ↓	Nominal Composition, %							Suggested Operating Range, F
	C	Mn	Si	Cr	Ni	Mo	Other	
17-7PH[a]	0.09[d]	1.0[d]	1.0[d]	16–18	6.5–7.75	—	Al 0.75–1.5	RT-600
PH15-7 Mo[a]	0.09[d]	1.0[d]	1.0[d]	14–16	6.5–7.75	2.0–3.0	Al 0.75–1.5	RT-800
AM 350[a]	0.08–0.12	0.50–1.25	0.5[d]	16–17	4–5	2.5–3.25	N 0.07–0.13	RT-800
AM 355[a]	0.10–0.15	0.50–1.25	0.5[d]	15–16	4–5	2.5–3.25	N 0.07–0.13	RT-800
422[b]	0.23	0.75	—	12	0.90	1.0	W 1.0, V 0.25	RT-800[e]
A286[c]	0.08[d]	1.0–2.0	0.40–1.0	13.5–16	24–28	1.0–1.5	Al 0.35[d], Ti 1.75–2.25	RT-1200

[a]Precipitation hardening. [b]Martensitic. [c]Austenitic. [d]Maximum. [e]After tempering at 800 F.

TABLE 2—TYPICAL COMPOSITIONS OF APPLICABLE SILVER-BASE BRAZING ALLOYS

Type ↓	Nominal Composition, %						Melt Temp, F	Flow Temp, F
	Ag	Mn	Cu	Li	Ni	Pd		
Ag-Li	99.8	—	—	0.2	—	—	1750	1750
Ag-Mn-Li	84.8	15	—	0.2	—	—	1700	1750
Ag-Cu (coin)	90	—	10	—	—	—	1650	1725
Ag-Cu-Li (sterling)	92.8	—	7	0.2	—	—	1625	1650
Ag-Cu-Li	71.8	—	28	0.2	—	—	1400	1400
Ag-Cu-Ni	62.5	—	32.5	—	5	—	1600	1725
Ag-Pd-Mn (SPM-1)	75	5	—	—	—	20	2000	2150

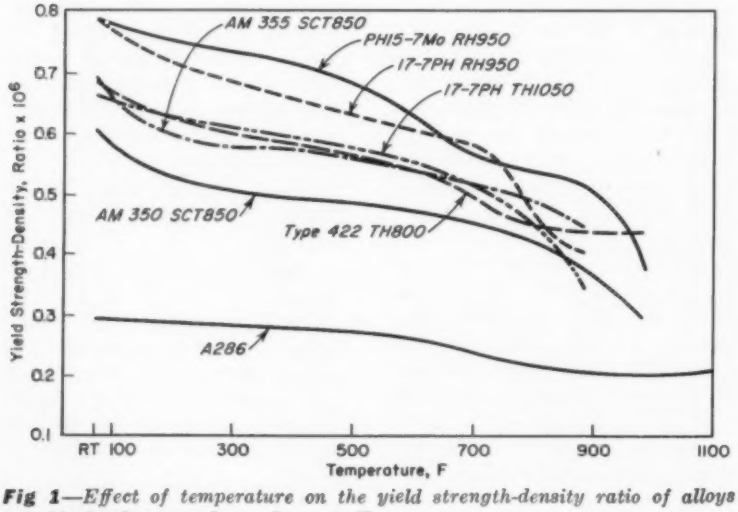


Fig 1*—Effect of temperature on the yield strength-density ratio of alloys suitable for honeycombs used at 800 F.*

■ Steel sandwich constructions for service at temperatures near 800 F can be formed by brazing. Brazed honeycomb construction is in use on the B-58 Bomber and is scheduled for use on the North American B-70 and F-108 aircraft. Although Martin has not yet fabricated production parts of brazed honeycomb, we have produced pilot-type hardware, such as quarter-scale rudder panels, that meet engineering specifications.

Selection of core and face materials

The primary requisites for materials for elevated temperature honeycombs are:

1. High mechanical properties at ambient temperatures, and retention of a high proportion of these properties at elevated temperatures.

2. Good corrosion and oxidation resistance.

3. Little or no distortion during heat treatment.

4. Good fabrication and joining characteristics.

5. Low strategic alloy content.

6. Low magnetic properties.

7. Low thermal expansion.

A survey of available materials indicated that the precipitation hardenable alloys—17-7PH, PH15-7 Mo, AM 350 and AM 355—and martensitic alloy 422 are suitable for brazed sandwich construction for service temperatures up to 800 F. Compositions of these alloys are given in Table 1. Yield strength-density ratios are given in Fig 1.

The precipitation hardenable alloys are solution treated at 1400 to 1750 F, air cooled to room temperature, subzero cooled to temperatures of –20 to –100 F, and aged at temperatures of 850 to 1100 F.

Martensitic alloy 422 is austenitized at 1825 F, air cooled to room temperature, and tempered at 800 to 1200 F. Although this alloy offers good strength and weldability, its corrosion resistance is marginal—a major problem in thin honeycomb materials which are generally only 1 to 2 mils thick.

Resistance welded preformed honeycomb core has evolved into many configurations including square cell, corrugated square cell (nine node), multiwave and sine wave. The square cell is the best core type for general use, but does not have the flexibility desirable for curved surfaces. Corrugated square cell and multiwave cores were developed for curved surfaces because they have greater flexibility than the square cell core. However, brazing the flexible cores is troublesome because of their tendency to relax at the brazing temperature, resulting in a spotty braze.

Selection of brazing alloys

Brazing alloys to be used with these materials should meet the following requirements:

1. Flow temperature coinciding with the conditioning and/or hardening temperature of the base alloy.

2. Corrosion and oxidation resistance compatible with the base alloy.

3. Minimum of alloying or diffusion to avoid embrittling the core.

4. Adequate wetting of the base alloy in the processing atmosphere.

Commercial brazing alloys that are useful with the base alloys discussed here fall into two types: silver-base and nickel-base. The nickel-base alloys are stronger and have greater oxidation resist-

How to Braze Honeycomb Structures

Brazing can be effectively accomplished by using:

1. Sealed retort containers heated in a conventional box-type furnace.

2. Retort furnaces, such as a hydrogen bell.

3. Vacuum retort furnaces.

4. Electric, radiant heat or quartz lamp-heated blankets.

5. Molten salt baths.

The method selected will depend on the heat treatment required for the base alloy, the brazing metal selected, the atmosphere, and the size and quantity of parts involved.

Regardless of the method, a completely brazed assembly will be obtained only if:

1. All detail parts such as core, faces, edge members and inserts are held to a thickness tolerance of ± 0.003 in.

2. The parts are cleaned. With adequate cleaning of the components, the quality of the joints is governed largely by the atmosphere.

3. A clean dry atmosphere free from impurities and having a dew point of about –100 F is provided.

Brazing methods

In sections over 1 in. thick, furnace brazing of the precipitation hardenable alloys 17-7PH and PH15-7 Mo in the RH condition with modified sterling silver produces poor fillets at the junction of the core and upper face because of the fluidity of the brazing alloy at the required temperature of 1710-1750 F. Fast brazing by blanket techniques is successful because the rapid heating and cooling cycles prevent excessive flow of the brazing alloy. Fluidity is not a problem with these alloys in the TH condition; brazing is done at 1650 F and is followed by the standard heat treating process.

Successful furnace brazing of the precipitation hardenable alloys 17-7PH and PH15-7 Mo in the RH condition can be achieved by the selection of an alloy such as 62.5 silver-32.5 copper-5% nickel which is more sluggish at 1710-1750 F than sterling silver. This alloy produces excellent filleting with little flow along nodular areas.

Another brazing technique that shows promise is the use of a 0.001-in. nickel shim coated with 0.001 in. of coin silver. The nickel shim holds the brazing alloy in place and the result is a satisfactory braze.

A third development uses a double layer of brazing alloy. The upper layer, consisting of the more fluid alloy, is supported by a second, higher melting alloy. The fluid alloy melts and combines with the second to form a third alloy. The result is a braze with even filleting.

Inspection

A critical factor in brazed honeycomb structures is inspection to determine whether a satisfactory braze has been produced. X-raying is the most reliable method of nondestructive testing at present. However, use of x-ray techniques is quite expensive because of the number of radiographs required to cover the structure adequately. In addition, the x-ray does not reveal the quality of the brazed fillet bond; it merely shows whether or not a fillet is present.

Although such methods as the infrared camera, the TV x-ray image, fluoroscopy, eddy currents and ultrasonics are being evaluated in an attempt to develop a low cost testing method, none has proved entirely satisfactory.

Properties of Honeycomb Structures

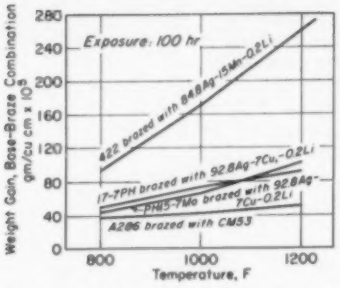


Fig 2—*Oxidation resistance (weight gain) for various base metal-braze combinations.*

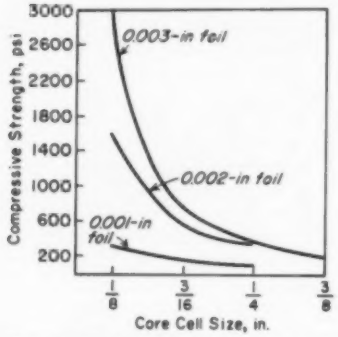


Fig 3—*Foil thickness vs compressive strength of annealed 17-7PH honeycomb.*

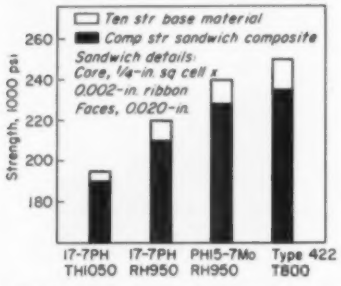


Fig 4—*Column compressive strengths for several honeycomb combinations.*

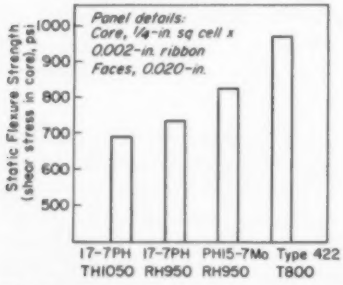


Fig 5—*Static flexure strengths for several honeycomb combinations.*

ance than the silver-base alloys. However, the nickel-base alloys have a tendency to embrittle—by alloying and grain boundary penetration—the foil produced from precipitation hardenable steels. For this reason and because the brazing temperatures are sufficiently high to cause excessive grain growth and reduced mechanical properties in the precipitation hardenable alloys, nickel-base alloys are not recommended.

Recommended brazing alloys (compositions in Table 2) for the specified base metals are:

For 17-7PH, PH15-7 Mo, AM 350, AM 355

- Sterling silver modified with 0.2% lithium
- Nickel-clad coin silver
- 62.5 silver-32.5 copper-5% nickel

For 422

- Pure silver modified with 0.2% lithium
- Nickel-clad coin silver

For A286 (included for comparison)

- Acrylic-bonded CM 53 (a nickel-chromium-silicon-iron-boron alloy).

Suitable methods for brazing with these combinations are discussed in the box on p 111.

Properties of honeycomb structures

Evaluation of the properties of brazed honeycomb structures is essential to determine whether these structures will meet the service requirements. Oxidation, column compression, static flexure and flexural fatigue tests have been applied to various materials with the following results.

Oxidation properties—Various combinations of base metal and braze alloy were tested in stagnant air at 800, 1000 and 1200 F for a period of 100 hr. The results are shown in Fig 2. A286 showed the greatest resistance to oxidation, although 17-7PH and PH15-7 Mo were also quite resistant. Least resistance was shown by 422.

Compression properties—Tests made on annealed 17-7PH square honeycomb core at room temperature show that the foil thickness and cell size have a pronounced effect on the strength of the core. As shown in Fig 3, structures made with 0.003-in. foil are much stronger up to cell sizes of ¼ in. than those made with thinner foil. In larger cell sizes the differences are not so great.

Column compression properties—Results of tests made on 3 by 8-in. specimens with an effective column height of 6 in. are shown in Fig 4. The highest strength is shown by 422 after tempering at 800 F. However, the use of this alloy in primary structures would be critical because of its low resistance to corrosion.

Static flexure properties—In these tests, the load is applied at the center of a 6-in. span. The properties of several honeycombs produced from precipitation hardenable grades and 422 are shown in Fig 5. In this test also, type 422 shows the highest strength.

Flexural fatigue properties—Fatigue tests were made only on A286 brazed with CM 53 brazing alloy, using a span of 6 in. and cyclic loading with R = 0.1 where R is the ratio of minimum to maximum applied stress.

Ambient temperature tests showed an endurance limit (10^7 cycles without failure) of 163 psi maximum core shear stress. At elevated temperatures the endurance limit increased—to 200 psi at 500 F and 180 psi at 1000 F. Failure occurred either in a combination of core-shear and braze-joint failure, or in face tension.

Stress corrosion properties—Atmospheric stress corrosion tests made on a 17-7PH-RH950 panel showed no failure after an exposure of 23 months.

Reference

Burrows, C. F., and Ragland, F. J., Jr., "Development of Brazed Sandwich Construction Materials for High Temperature Applications," WADC Tech. Report 55-463, Part 2, '57.

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by John L. Everhart, *Technical Editor, Materials in Design Engineering*

Ford Motor Co.

Complex shapes *are formed in one operation by powder metallurgy.*

Designing for Metal Powder Structural Parts

Metal powder compacts can provide outstanding service at minimum cost for engineers and designers who are familiar with their advantages and limitations. This manual will help you determine the properties of various powder mixtures, and select suitable designs and applications that will take full advantage of these properties. The manual covers:

- *Ferrous and nonferrous materials*
- *Design rules and pointers*
- *Finishing*
- *Economics of using metal powder parts*
- *Typical applications*

■ Powder metallurgy offers the designer and engineer a means of obtaining a wide range of characteristics in a variety of metallic compositions at reasonable cost. However, to use the process efficiently, it is necessary to know both its advantages and its limitations.

Density and porosity

A major advantage of powder metallurgy is control over the properties of the part. Sintered iron powder, for example, yields parts having tensile strengths of the order of 30,000 psi. This figure compares with 50,000 to 80,000 psi obtainable with cold rolled steel. Higher strength iron powder parts can be obtained by increasing the density in one of four ways: using higher briquetting pressure, using powders having greater compressibility, coining after sintering, or infiltrating the part with a lower melting metal such as copper. With such treatments, tensile strengths of 50,000 to 100,000 psi can be obtained.

The reciprocal of density is, of course, porosity. Porosity may be useful or detrimental. It is useful when filled with oil or other liquids for lubrication or to prevent corrosion. It is detrimental in many structural parts because it reduces such properties as elongation and hardness. Because pores are usually interconnected in low density parts, porosity may result in internal corrosion and consequently a shorter life for the part or the destruction of finishes applied to the surface. In addition porosity prevents the use of parts in pressure systems since liquids or gases can leak through.

To take full advantage of powder metallurgy, the designer should determine the strength, ductility and hardness required. These will be related to the density required. In some cases, heat treatment will obviously be necessary, but in many cases metal powder parts can be used without subsequent heat treatment. By determining the properties required the engineer can avoid paying a higher price than necessary to obtain a part that will function satisfactorily.

The four types of parts

Metal powder products can be divided broadly into four groups:

1. Parts having densities of the order of 50%. These parts are used as filters and in similar applications.
2. Parts having densities of the order of 75%. Such parts are used in applications like the familiar self-lubricated bearing.
3. Parts having densities ranging from about 80 to above 95%. These parts are used in structural applications.
4. Infiltrated parts having practically full final density. These parts are also used in structural applications.

The purpose of this manual is to help the engineer or designer determine the properties of various powder mixtures, to help him select suitable designs to take full advantage of these properties, and to point out to him various applications that have been handled successfully. Because of space limitations, only the last two groups—structural parts—are covered in this manual.

Properties of metal powder parts

Parts produced from metal powders range from low strength, relatively soft, porous bodies to high strength, hard carbides. Properties are influenced by a number of factors that are unique. All metal powder parts are affected to varying degrees by:

1. Powder production method. Powders produced from reduced oxides have pressing characteristics different from those produced by electrolysis.

2. Particle size. Similar compositions produced from powders of different particle size can have quite different properties.

3. Pressing practice. Differences in density can occur during pressing of complicated parts, with the center of the part having lower density than the ends, particularly in long parts.

4. Sintering conditions. The furnace atmosphere and sintering conditions can affect properties significantly. Parts introduced directly into the hot zone can have properties that differ from those of parts introduced into the hot zone through a preheat zone, since sintering time and temperature affect the degree of alloying obtained.

The combination of all of these factors can cause variations in the density of individual parts, from part to part and from lot to lot, unless proper controls are maintained.

The factors just mentioned are important because of their influence on density. Density, itself, is a major consideration in the production of metal powder parts. Its influence is so great that tensile strength may be as much as 75% lower than the maximum obtainable from the particular powder mixture if density is low. Therefore, users of metal powder parts should consult the parts producer to determine whether the desired strength-density combination can be produced from the desired powder mixture.

These preliminary remarks are necessary for an understanding of the properties of specific compositions, which will be discussed under the following two sections on 1) ferrous parts and 2) nonferrous parts.

Ferrous parts

Ferrous powder parts are made from iron, copper-infiltrated iron, steel and stainless steel compositions. Some of these materials are covered by ASTM specifications; these compositions and a list of typical properties are given in Table 1. Ferrous compositions are further specified as low density, medium density and high density parts (infiltrated grades are properly classified under high density).

Pressed and sintered parts—Plain iron fits the requirements of the large field of low and medium density parts, although its strength is rather low. Strength can be improved by increasing the density, but greater improvement results from the use of additional elements in the powder mixture. Among such additions are carbon and copper. Parts containing carbon can be heat treated to increase strength and hardness. Copper, in small quantities, enters the iron matrix and improves the strength. Using carbon and copper together makes it possible to obtain good mechanical properties with lower carbon contents than are possible with carbon alone.

The properties of various low density, medium density and high density ferrous metal parts are given in Table 2. These values have been collected from many sources, which, unfortunately, give very little information on the treatments used. How-

ever, this table does indicate 1) the effects of density on mechanical properties (within the range of densities obtainable by pressing and sintering), and 2) the range of properties obtainable by pressing and sintering.

Infiltrated parts—Table 2 also shows properties of high density parts produced by infiltration. Porous iron parts having densities of 60 to 80% of theoretical can be infiltrated with various lower melting metals and alloys. Among those preferred are copper, copper-iron, copper-iron-manganese and various brasses. Residual porosity is reduced to less than 4% by this procedure. The infiltrated irons have tensile strengths of the order of 50,000 to 60,000 psi and elongations of 14 to 30%. If copper is included in the alloy used for infiltration the part can be precipitation hardened to obtain strengths up to 100,000 psi and elongations up to 8%. These properties are superior to those obtainable by pressing and sintering powder mixtures of the same composition.

Heat treated parts—Iron powder parts containing carbon can be heat treated by procedures used for conventional steels. The response will depend, of course, on the quantity of carbon that has combined with the iron during sintering. Taking advantage of the fact that porosity is present, it appears more common to use carburizing or carbonitriding heat treatments than simple quenching and tempering operations.

Iron powder parts can be carburized by heating in controlled atmospheres (see Fig 1). Ease of controlling the carbon content and formation of a case varies with the density. Because of the porosity, low density parts (having 75 to 85% theoretical density) are most difficult to carburize uniformly. Careful control is necessary, but machine parts have been satisfactorily carburized despite low density. Medium density parts (85 to 95% theoretical density) are less difficult to carburize; carbon penetration is faster than in the carburizing of conventional steels. High density parts (above 95% theoretical density) are readily carburized by conventional procedures. Table 3 compares the properties of some heat treated powder parts with those of wrought steels.

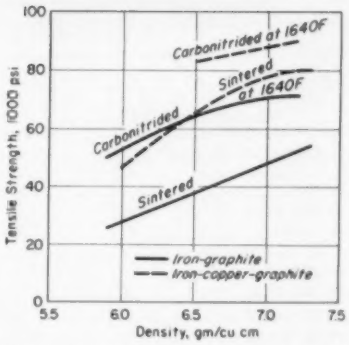


***Fig 1**—Case hardened parts develop higher strengths after heat treatment than parts of the same composition which are pressed and sintered.* (Kothari)

Steam heat treatment has also been used to produce an oxide coat-

TABLE 1—ASTM REQUIREMENTS AND TYPICAL PROPERTIES

Material	ASTM			Composition, %[a]				Typical Properties[e]			
	Specified Density, gm/cu cm	Number	Class	Fe	Cu	C	Other	Density, gm/cu cm	Ten Str, 1000 psi	Elong (in 1 in.), %	Compr Yld Str (0.1% offset), 1000 psi
Low Density Iron	5.7-6.1	B310-58T, Type I	A	96.25[b]	—	0.25[c]	3.0[d]	5.7	14	1.5	10
			B	95.9[b]	—	0.25-0.60	3.0[d]	5.7	17	1.0	15
			C	95.5[b]	—	0.60-1.0	3.0[d]	5.7	22	0.5	20
Medium Density Iron	6.1-6.5	B310-58T, Type II	A	96.25[b]	—	0.25[c]	3.0[d]	6.5	24	4.0	18
			B	95.9[b]	—	0.25-0.60	3.0[d]	6.5	27	2.0	23
			C	95.5[b]	—	0.60-1.0	3.0[d]	6.5	35	0.5	27
High Density Iron	6.90-7.29	B309-58T	A	97.9[b]	—	0.15[c]	1.5[d]	6.9	30	7.0	25
	7.30[b]	B309-58T	B	97.9[b]	—	0.15[c]	1.5[d]	7.3	37	11.0	30
Copper Infiltrated Iron	7.1-7.6	B303-58T	A	71.25-85.00	15-25	0.25[c]	3.0[d]	7.35	65	1.0	70
			B	70.90-84.75	15-25	0.25-0.60	3.0[d]	7.35	75	1.0	90
			C	70.50-84.40	15-25	0.60-1.0	3.0[d]	7.35	100	0.5	120
Iron-Copper	5.8-6.2	B222-58	...	86.5[b]	7.0-11.0	0.3[c]	2.5[d]	5.8	29	0.5	28.5
								6.2	34	1.0	30
Bronze	6.4-6.8	B255-58T	A	1.0[c]	87.5-90.5	1.75[c]	Sn 9.5-10.5	6.4	13.5	1.0	11
	6.8-7.2	B255-58T	B	1.0[c]	87.5-90.5	1.75[c]	Sn 9.5-10.5	7.2	20	3.0	20
Brass	7.2-7.7	B282-58T	A	0.25[c]	77.0-80.0	—	Pb 1.0-2.0, Zn Bal	7.2	20	9.0	10
	7.7[b]	B282-58T	B	0.25[c]	77.0-80.0	—	Pb 1.0-2.0, Zn Bal	8.0	27	13.0	14

[a]For minor constituents see specification. [b]Minimum. [c]Maximum.
[d]Unspecified elements determined by differences, maximum. [e]Not specification values.

TABLE 2—PROPERTIES OF SOME FERROUS METAL POWDER PARTS[a]

Nominal Composition, %	Density, gm/cu cm	Ten Str, 1000 psi	Elong (in 1 in.), %	Compr Yld Str (0.1% offset), 1000 psi	Rockwell Hardness
LOW DENSITY IRON (5.7-6.1 gm/cu cm)					
Fe 100	6.0	18	3.0	—	F65
Fe 99.5, C 0.5	5.7-6.1	25	1.5	20	B20
Fe 99, C 1.0	5.7-6.1	15-35	0.1-1.0	13-35	B30-40
Fe 99, Cu 1.0	6.0	16	1.0	22[a]	H60
Fe 96.5, Cu 3, C 0.5	6.0	32	0.1	—	B30
Fe 94.5, Cu 5, C 0.5	6.0	32	1.5	—	B30
Fe 95, Cu 4, C 1.0	5.8-6.1	25	0.5	20	B25-45
Fe 94, Cu 5, C 1.0	6.0	37	1.0	—	B50
Fe 90, Cu 10	5.8-6.2	30-40	0.5	32-45[b]	H94-B35
MEDIUM DENSITY IRON (6.1-6.5 gm/cu cm)					
Fe 100	6.5	22-26	2-5	18-21	F20-30
Fe 99.4, C 0.6	6.5	35	0.5	27	B35-45
Fe 99, C 1.0	6.2-6.5	25-42	0.5-1.0	23-40	B40-50
Fe 97, Cu 2, C 1.0	6.5	60	1.5	—	B60
Fe 95, Cu 5, C 1.0	6.5	42	0.5	—	B50
Fe 94.5, Cu 5, C 0.5	6.2-6.5	64	0.2	60	B90
Fe 93, Cu 7	6.2-6.5	45	1.0	40	B48
Fe 60, Cu 40	6.3	15	6.5	18[b]	H65
HIGH DENSITY IRON (6.8 gm/cu cm min)					
Fe 100	6.9-7.6	30-45	7-18	20-25[b]	B42
Fe 99.5, C 0.5 (heat treated)	7.0	120	1.0	150	—
Fe 99, C 1.0	6.8-7.6	45-75	1.0	40-90	B50-85
Fe 97, Cu 2, C 1.0	7.0	100	2.5	—	B75
Fe 94, Cu 5, C 0.7	6.8	80	1.0	—	B82
Fe 93, Cu 7	6.9	52	2.5	—	B56
Fe 92, Cu 7, C 1.0	6.8	104	1.0	—	B89
COPPER-INFILTRATED IRON					
Fe, C 1.0, Cu[c]					
Infiltrated	7.1-7.6	75	1.0	90	B85
Heat Treated	7.1-7.6	120	0.4	100	C40
Fe 85, Cu 15					
Infiltrated	7.9	60-75	16	—	—
Heat Treated	7.9	60-125	14	—	—
Fe 84, Cu 15, C 1.0					
Infiltrated	7.9	80-110	6	—	—
Heat Treated	7.9	85-185	11	—	—
Fe 75, Cu 25					
Infiltrated	8.0	50-65	13	—	—
Heat Treated	8.0	50-100	18	—	—
Fe 74, Cu 25, C 1.0					
Infiltrated	8.0	70-90	7	—	—
Heat Treated	8.0	80-160	10	—	—
LOW ALLOY STEELS					
C 0.30, Mn 0.50, Si 0.25, Ni 1.7, Mo 0.25	6.9	60	0.5	60[b]	C25
C 0.30, Mn 0.50, Si 0.25, Ni 1.85, Mo 0.25	7.5	115	1.5	80[b]	C30
C 0.75, Ni 3.5					
Sintered	6.6-7.2	50-68	2.5-5	—	B66-B71
Heat Treated	6.6-7.2	100-148	1-2.5	—	C22-C50
C 0.75, Ni 7.0					
Sintered	7.23	93	4	—	B90
Heat Treated	7.26	138	2.5	—	C52
STAINLESS STEELS					
Cr 14.5	6.7	45	20	—	—
Cr 18, Ni 8	6.4	40	7	45	—
Cr 17, Ni 11, Mo 2.5	6.7	50	7	35[b]	B55

[a]These data are not strictly comparable since they were obtained from many different sources which gave little information on fabricating conditions.
[b]0.2 offset. [c]Composition not specified.

ing on the surface and in the pores of iron powder parts. This treatment increases hardness, strength and corrosion resistance, improves wear resistance, and imparts a uniform blue-black finish to the part.

Nonferrous parts

The nonferrous metals are more widely used in porous than in structural parts, but the brasses, in particular, are becoming important in structural applications. Compositions specified by the ASTM are given in Table 1 together with typical properties that will be obtained in these parts.

Table 4 gives the properties of a variety of nonferrous metal parts. These properties were gathered from many sources and little information was given on the conditions under which the parts were produced. However, the table gives an idea of the mechanical properties that can be obtained by pressing and sintering the compositions specified.

Quite a few other nonferrous materials are produced from powders, including molybdenum, beryllium and tungsten. In general, however, the powder is used only as a step in the production of mill shapes such as strip, rod, tubing or wire, and only on rare occasions in the direct production of a metal powder part. Titanium and aluminum metal powder parts are under development.

Design of metal powder parts

Structural parts that can be made successfully depend largely on the possibilities of the briquetting operation. Metal powders do not flow freely; friction between particles, and between particles and die walls, prevents flow—especially in long, narrow cavities. Therefore, unless provision is made for proper powder distribution, the volume of powder in the die may be insufficient in some areas and excessive in others.

Since there is practically no lateral flow in the die, the proper quantity of powder must be placed exactly where it is required in order to obtain uniform density. This requirement is particularly essential in producing parts with thin walls or variable cross sections. The fact that powders do not flow laterally also places some limitations on contours that can be produced in the

pressing operation. Some of the points which a designer must bear in mind follow.

Design pointers

Length-to-diameter ratio — The length should be proportional to the diameter of the part. Excessively long parts are usually less dense in the center than at the ends. Usually a length-to-diameter ratio of 2½-to-1 is the commercial limit of practical operation, although parts having ratios as high as 7-to-1 have been produced successfully.

It may be possible to redesign a part or modify it to compensate for variation in cross section. For example, a boss on one face, sufficiently high to make a significant difference in cross section, might be compensated for by a corresponding recess in the opposite face, or by ribbing.

Parts with multiple steps can be molded but the difference between steps or offsets must be 0.032 in. min. It is often preferable to reduce the number of variations in cross section that are pressed and complete the part by machining some of the stepped sections.

Bosses—The height of a boss is limited by the thickness of the collar and the projection of the collar from the main body of the part. To permit withdrawal of the upper punch, the slope of the edge of the boss must be at least 0.008 in. per in. If the diameter of the part is less than 3/32 in., the height of the boss cannot exceed the height of the collar. If the diameter is greater than 3/32 in., the height of the boss can be 1½ times as high as the collar.

Draft angles—An advantage of the metal powder process is the elimination of draft angles in most cases. However, there are special cases—bosses, for example—where draft is required. A draft is also required on a flanged part having a shoulder, if the thickness of the flange is greater than 3/32 in. and the width of the shoulder is less than the thickness of the flange. The draft angle should be ½ deg.

Splines—Cylindrical and symmetrical splines are preferred. Avoid splines that are narrow in relation to depth; dies for such splines are difficult to construct and costly to maintain. The width should not be less than one-third the length of the fin, and should never be less than 1/16 in. Radii at tips or base of the fins should not be less than 1/64 in.

TABLE 3—COMPARISON OF HEAT TREATED IRON POWDER PARTS AND WROUGHT CARBON STEELS[a]

Material	Heat Treatment	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Rockwell Hardness
Iron Powder[b] (0.95% C)	O.Q., Temp 600 F	170	160	1	C48
AISI C1095	Same	182	119	10	C42
Iron Powder[b] (0.95% C)	O.Q., Temp 800 F	138	120	2	C36
AISI C1095	Same	175	112	12	C36
Iron Powder[b] (0.95% C)	O.Q., Temp 1000 F	100	86	4	C25
AISI C1095	Same	158	98	15	C31
Iron Powder[b] (0.80% C)	O.Q., Temp 600 F	160	155	4	C46
AISI C1080	Same	189	143	11	C39
Iron Powder[b] (0.40% C)	O.Q., Temp 400 F	125	104	3	C50
AISI C1040	W.Q., Temp 400 F	130	97	16	C51

[a]Data determined on parts of different cross section. Therefore they indicate only relative properties of materials.
[b]Iron powder parts pressed to density of 7.5 gm/cu cm, through-carburized to carbon content indicated.
Source: *Doelker.*

TABLE 4—PROPERTIES OF SOME NONFERROUS METAL POWDER PARTS

Nominal Composition, %	Density, gm/cu cm	Ten Str, 1000 psi	Elong (in 1 in.), %	Compr Yld Str (0.1% offset), 1000 psi	Rockwell Hardness
COPPER					
Cu 100	8.0	20	8	15	—
	8.3	26-27	15-19	14-18	H70-75
BRONZE					
Cu 95, Sn 5	7.6-8.0	22	5	20	H47
Cu 90, Sn 10	6.6-7.2	15-20	2-3	13-20	H35-65
Cu 89.5, Sn 9.5, C 1.0	6.4-6.8	15	1.5	13	H24
Cu 88, Sn 10, Pb 2	6.8-7.2	19-26	10-13	—	H55-65
Cu 86, Sn 10, Pb 4[a]	6.6-6.8	12-14	3-4	—	H32-44
Cu 77, Sn 8, Pb 15[a]	5.8-6.2	4-6	3-4	—	—
Cu 68, Sn 10, Pb 22[a]	6.7-7	10-12	5	—	H19
BRASS					
Cu 90, Zn 10	7.6-7.9	22	10	—	H65
Cu 88.5, Zn 10, Pb 1.5	7.6-7.9	20	12	—	H50
Cu 85, Zn 15	7.6-7.9	27	12	—	H74
Cu 80, Zn 20	7.7	33	20	—	—
Cu 78.5, Zn 20, Pb 1.5	7.5	21	15	12[b]	H70
Cu 70, Zn 30	7.3-7.6	27	8	—	H80
NICKEL SILVER					
Cu 70, Zn 20, Ni 10	7.5-7.8	29	10	—	H78
Cu 64, Zn 18, Ni 18	7.3-7.8	20-32	2-10	18	H75-92
Cu 64, Zn 16.5, Ni 18, Pb 1.5	7.5-7.8	23	15	—	H80
NICKEL					
Ni 100	6.7-7.7	18-27	7-9	—	—
	7.4-8.1	30-37	7-10	—	—
TITANIUM					
Ti 100	4.1	74-77	6	—	B50
Ti 100 (hot pressed)		58	35[c]	—	A48
TUNGSTEN					
W 90, Ni 6, Cu 4	16.9	85-120	2-10[c]	—	C10-40
W 90, Cu+Ni 9, Other[d]	16.7-17.1	120	6[c]	—	C20-30

[a]Plus graphite. [b]0.2% offset. [c]In 2 in. [d]Unspecified. [e]In 4D.

Advantages and Limitations of Powder Metallurgy

Advantages

1. Rapid, automatic production, with low scrap losses and minimum of subsequent machining operations.
2. Close tolerances and smooth surfaces.
3. Use materials that cannot be alloyed by conventional methods.
4. Production of parts containing mixtures of metallic and nonmetallic constituents.
5. Control of density and porosity, with resulting control of properties.

Limitations

1. Shape of parts somewhat limited.
2. Length and concentricity tolerances more liberal than those obtained by machining.
3. Difficulties in producing complex shapes with non-uniform cross sections that have uniform density.
4. High tooling and equipment costs, generally necessitating volume production.
5. Relatively high cost of metal powders.
6. Limits on properties obtainable.

Knurls and serrations—Diamond knurls or horizontal serrations cannot be produced by pressing. Vertical serrations can be molded. To minimize tool costs, radii at edge and base of the serrations should be at least 0.008 in.

Chamfers or bevels—Chamfers with a maximum angle of 45 deg ending in a shoulder are frequently used to break edges. Chamfers or bevels less than 30 deg cannot be molded because the use of such angles will force the construction of punches with feather edges.

Corner reliefs—Reliefs can be formed at the junction of a flange and the body of the part if they run in the pressing direction. At right angles to the pressing direction, reliefs are a reentrant form that cannot be pressed but must be machined after the part has been sintered.

Longitudinal holes—Holes to be formed in the pressing direction offer no particular problem unless they are very small, in which case the core rods may offer problems because of breakage. Although round holes simplify tooling, square, rectangular or irregular shapes can be formed. Length to diameter ratio should be held to 4-to-1. Holes smaller than 3/16 in. may involve expensive tooling; holes closer than 1/16 in. to the edge of the piece may introduce structural problems.

Holes with blind ends can be molded if the part does not have a flange or offset opposite the blind end. A part with a blind hole starting at one end and an offset on the other end cannot be ejected from the die.

Shapes that cannot be molded—Although new techniques in tooling and side motion compacting make it possible to produce some of them with special equipment, generally the following details cannot be molded:

1. Reentrant grooves, recesses and undercuts.
2. Parts having a taper in the direction that would form a reentrant angle.
3. Holes at right angles to the direction of pressing.
4. External and internal threads.

All of these contours must usually be introduced by secondary operations after the part has been sintered.

TABLE 5—TYPICAL TOLERANCES FOR PARTS OF UNIFORM CROSS SECTION[a]

Dimension ↓	Ferrous Parts				Nonferrous Parts	
	After Sintering		Sized		Sized	
	Normal	Close[b]	Normal	Close[b]	Normal	Close[b]
Length, in./in.	±0.005	±0.003	±0.003	±0.002	±0.003	±0.002
Inside Diameter, in./in.	±0.002	±0.001	±0.001	±0.0005	±0.0015	±0.0004
Outside Diameter, in./in.	±0.002	±0.001	±0.001	±0.0005	±0.0015	±0.0004
Concentricity, TIR	0.003	0.002	0.002	0.0015	0.003	0.002
Flatness of Ends, in./in.	±0.002	±0.001	±0.001	±0.001	±0.001	±0.001
Parallelism of Ends, in./in.	±0.0015	±0.001	±0.001	±0.001	±0.001	±0.001

[a]Tolerances vary somewhat with the producer. Figures are for parts of reasonable size.
[b]Depends on condition of tools.

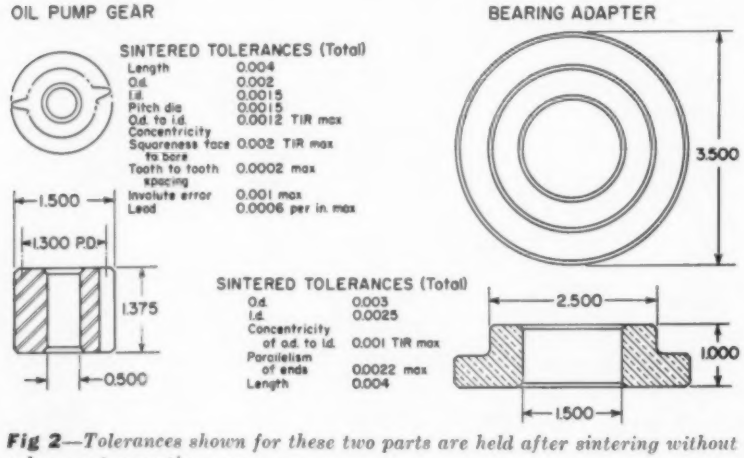
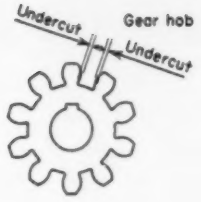


***Fig 2**—Tolerances shown for these two parts are held after sintering without subsequent operations.* (Burgess)

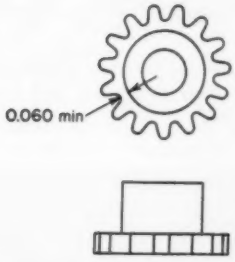
Tolerances

The nature of the process and the variables that can be introduced during pressing and sintering have considerable influence on the tolerances that can be held. Closer toler-

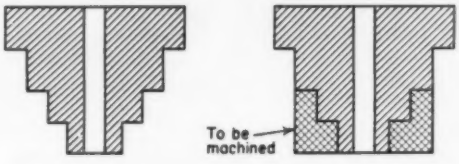
Some Design Pointers



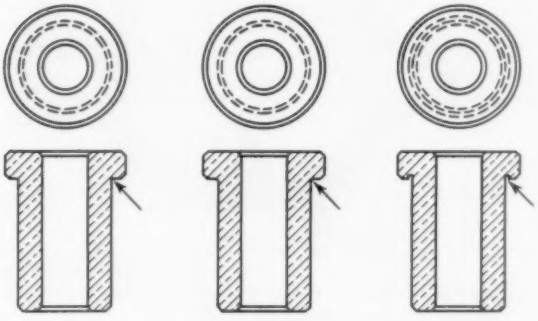
True involute gear form *can be molded. This form cannot be hobbed because of the profile undercut.*



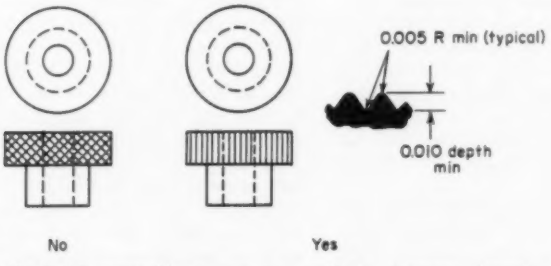
Section thickness *between root diameter of gear and outside diameter of neck must be at least 0.060 in.; on large diameter gears this distance must be increased.*



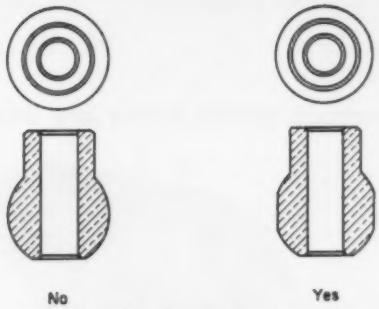
Extensive stepped diameters, *if compacted, result in lower strength of the part. It is preferable to machine some of the steps.*



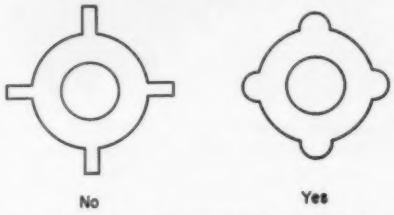
Fillets or radii *are required at all right angles. If a fillet cannot be tolerated, an undercut can be molded as shown at right.*



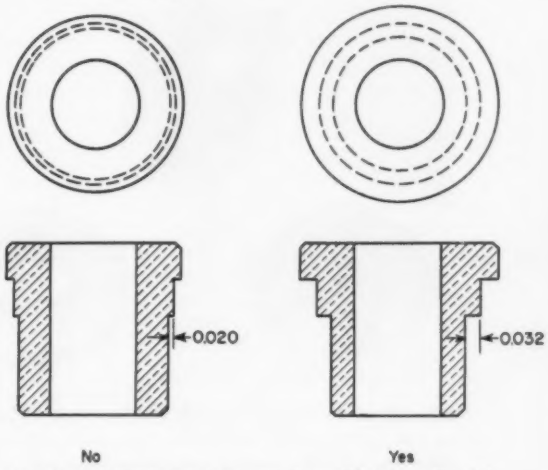
Straight serrations *can be molded; diamond knurls cannot.*



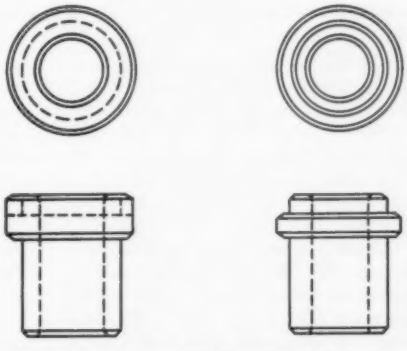
Ball-shaped parts or spheres *can be molded but a flat area is required to prevent contact of molding punches.*



Cylindrical and symmetrical flutes *are preferred. Avoid flutes that are narrow and deep.*



Multiple-stepped parts *can be molded but the difference between steps must be a minimum of 0.032 in. Wall sections less than 0.032 in. increase tool maintenance costs.*

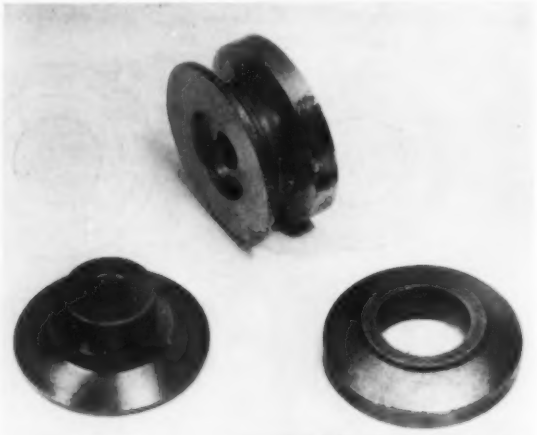


Flanges *are preferably made by pressing the cylinder shown at left and machining to produce the flange (right).*

Ferrous metal parts are used for

National-U.S. Radiator Corp.

Quadrant gear *used in domestic washing machine is required to withstand high impact loads.*
Material: Copper-infiltrated iron powder.

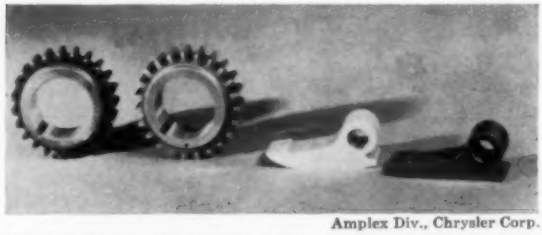


National-U.S. Radiator Corp.

Wheel *for broiler tray in domestic range is compacted in two parts, using powders of different characteristics (one has negative growth, the other positive). Upon sintering, a single strong part is formed. After sintering, part is impregnated with resin, then plated with copper and nickel.*
Material: Iron powder.

Powdercraft Corp.

Integral face and disk cam *for various applications. Such cams are produced to close tolerances and carburized and hardened before use.*
Material: Iron powder.



Amplex Div., Chrysler Corp.

Timing chain sprockets *(left) and transmission kickdown levers for Chrysler automotive transmissions.*
Material: Iron-base powder.

Moraine Products Div., GMC

Latch plate *for automotive use is heat treated to estimated tensile strength of 130,000 psi.*
Material: Iron-carbon powder impregnated with copper.

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ances are practical on radial than on longitudinal dimensions; radial dimensions are controlled by the accuracy imparted to the dies and punches, whereas longitudinal dimensions depend on the motion of the press and the accuracy of filling the die.

Table 5 gives representative tolerances for ferrous metal powder parts as sintered and after sizing, and for nonferrous parts after sizing. The table was developed from a questionnaire answered by a representative group of metal powder parts producers. Caution is necessary in the use of this table. There was considerable spread in values from one extreme to the other, possibly resulting from differences in equipment and processing technique. Therefore, the table should not be considered as an industry-wide specification of tolerances but merely as an indication of values that can be held on simple shapes of moderate size.

Fig 2 is more specific. The figures given cover tolerances that are held by a single producer on iron powder parts of the configurations shown. They indicate some of the variables resulting from part size and shape.

The parts shown in the drawings are relatively simple. Tolerances that can be held on more complex parts will require investigation. Unless a simple configuration is involved, the designer should consult the parts producer on each specific part before setting tolerances. Failure to do so may lead to the specifications of tolerances that can be held only with difficulty or obtained only by secondary operations. Both methods of meeting specifications are costly.

Finishing of metal powder parts

Although sintered parts usually have a matte finish, the surface can be plated to improve resistance to corrosion or abrasion or for decorative purposes. Silver or copper plating improves electrical conductivity; tin plating increases solderability. Chromium, nickel, cadmium, zinc and other metals are used to improve durability or appearance.

The principal factors that influence the corrosion resistance of electroplated powder parts are density of the part, copper content of the part, and throwing power of the bath. Cadmium plates of uniform, smooth quality with good corrosion resistance are produced in a cyanide bath. Zinc plates are produced better and faster in sulfate baths than in cyanide baths. Nickel plates that are smooth and uniform can be obtained on low density, high density and impregnated parts with a nickel sulfamate solution. Smooth deposits with uniform appearance can be obtained by depositing copper from either copper sulfate or copper cyanide baths. Chromium plates are formed in chromic acid-sulfuric acid baths at relatively high current densities.

Corrosion resistance is improved by infiltration with compounds such as sodium silicate, with or without semicolloidal metal fillers, or styrene with linseed oil. Porous iron parts impregnated with such sealants are said to withstand up to 700 hr in a salt spray test.

Surface preparation

Surface porosity dictates choice of the best plating method. Materials having more than 95% of theoretical density have isolated surface pores and can be plated by the normal procedures used for wrought materials. In materials having densities of 85 to 95% of theoretical, porosity makes plating a problem and special preparatory measures are required. Pores are usually closed by impregnation, by working the surface mechanically, or by heat treatment.

Ferrous parts can be prepared for plating by infiltration with copper to close the pores. This procedure provides a conductive surface for subsequent deposition of nickel or chromium. Another method of closing the pores is to vacuum-impregnate the part with thermosetting styrene polyester. Parts treated in this manner are reported to be pressure tight to over 5000 tsi and usable at temperatures up to 400 F.

Brass parts can be prepared for plating by polishing and buffing to close the surface pores. After the part is copper plated with a thin film, it is rebuffed and subsequently plated with nickel or chromium. If a perfectly smooth finish is not required in the finished part, the copper plating step can be eliminated.

An alternate procedure to impregnating the pores is to electroplate the unsintered compact, give it a neutralizing dip and sinter in the usual manner. Because the surface pores tend to close in the final stages of sintering, the plated coating may diffuse into the surface and improve the adherence. Surface alloying can also be achieved by plating with layers of copper and tin or other metal combinations, followed by heating at a sufficiently high temperature to cause diffusion. If copper and tin are used, bronze is produced by this treatment.

Plating problems

Spotting-out is the major problem in plating porous metal parts. Acids and salts from the electrolyte have a tendency to become trapped in the interconnected pores of the part. Unless the liquids are removed or neutralized they tend to exude from the surface pores, causing the plated finish to discolor or flake off.

Discoloration has been observed after storage of copper-bearing, low density iron parts plated with cadmium, zinc or copper. No discoloration appeared on low density parts plated with chromium or nickel, or on high density parts plated with chromium, nickel and copper, after similar storage.

Economics of the use of metal powder parts

The economics of replacing machined, forged, cold formed or similar parts by metal powder parts are worth considering. In some cases, pressing and sintering close to final dimensions is the cheapest production method. In other cases, final sizing and machining operations, necessitated by close tolerances and contours that cannot be pressed, increase the cost, and other methods of production may be more economical than powder metallurgy. The individual part must be studied to determine whether it can be produced economically by powder metallurgy; the mere fact that considerable machining is required to produce a part does not make it a "natural" for the metal powder process.

Metal powders usually cost more than the raw materials used for the production of similar parts by other methods. Tools and dies are expensive, and a minimum number of parts must be produced from a set of dies to justify their cost. On the other hand, tooling can be developed quite rapidly. It has been estimated that tooling for the production of a metal powder part in the automotive industry requires several weeks, compared with the several months that are required for a conventional machined part. This difference permits advancing the lead time for production. In addition, elimination of many machining operations reduces operator costs and releases machines for other operations.

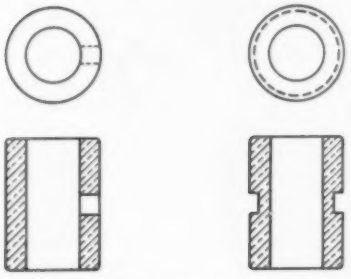
Production volume

Unless the process is required in order to obtain special properties, powder metallurgy is usually economical only for high volume production. The reasons are the need for expensive tools and the cost of tooling changes. It may require 1 to 30 hr to prepare the tools for production, and parts can generally be produced at rates of 500 to 5000 per hr. Minimum total production for economical operation is generally considered to be 50,000 pieces. Like all production figures, this one is a generalization, subject to modification with varying conditions.

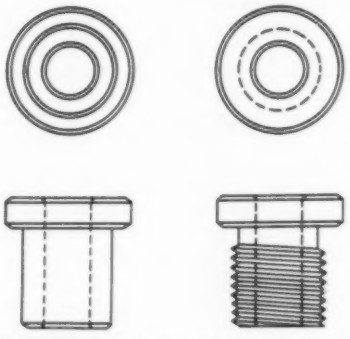
For example, one organization is saving 40 to 80% of the normal cost of a part with powder metallurgy production rates as low as 1000 parts per year. However, the saving results from meeting certain rigid requirements:

1. Design specifically for production as a metal powder part.
2. Careful design of tools.
3. Standardization to reduce the

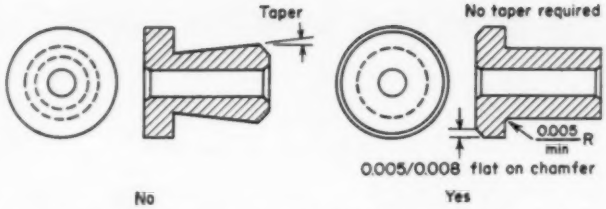
Shapes That Require Secondary Operations



Holes at right angles *and external grooves cannot be molded. They must be machined later.*



Threads *cannot be molded. Both external and internal threads must be cut after sintering.*



Reverse tapers *cannot be molded. They must be formed as shown at right and machined.*

number of different parts and make possible the use of one set of tools to produce several parts.

4. Strict process control to eliminate variables and minimize reworking of parts.

In another organization, it has been found economical to produce as few as 50 parts per month. In this case, production of the part by conventional methods would require an excessive number of machining operations. Thus there is no hard and fast rule for the quantity that can be produced economically.

Part size

The size of part that can be produced is limited by press capacity. Most commercial parts range in cross section from ⅛ to 50 sq in. and have lengths between 1/32 and 6 in. However, a number of companies have installed large presses and have greatly increased the size of parts produced; one organization supplies parts up to 30 in. in dia.

In deciding the size of part that can be produced by powder metallurgy, restrictive factors such as wall friction, internal friction and differences in pressure required for different powder mixtures can be overcome by increasing press capacity.

Production rate

Production rate can be a deciding factor in determining whether the metal powder part can compete economically with parts produced by other methods. Many large self-lubricating bearings are produced on relatively slow speed hydraulic presses. Although this procedure increases the cost, no other production method can be used and therefore low speed production is economically practical.

However, parts that must compete with those produced by such processes as die casting and forging must be produced at relatively low cost or much of the advantage of the powder metallurgy process is lost. Although structural parts can retain self-lubricating features and other unique properties, they must compete primarily on a cost basis; ability to compete is closely associated with production rate.

Production rates vary with the size and shape of the part and the type of pressing equipment. Basically, three considerations enter into the determination of the speed at which a part can be compacted. These factors are 1) size, shape and/or wall thickness of the part, 2) press speed available, and 3) flow properties of the powder mixture. Each of these three basic factors has its own variables.

Size and shape—Size of the part is tied up with press capacity. However, shape can have an important influence on production rate. A part that is sufficiently complex in shape to require multiple motion to form the compact and eject it from the die obviously cannot be produced as fast as a simple shape.

Press speed—Speed of the press depends on its size and type; assuming the density required makes it necessary to use 30 tsi pressure, a ½-in.-dia part can be produced on a 10-ton press but a 2-in.-dia part will require a press of about 100 tons capacity. The speed of the smaller press will be higher than that of the larger one.

Production rate is also influenced by the rate of filling the die. Uniform fill is essential because the quantity of powder from which a part is pressed controls both dimensions and density. To obtain parts within normal tolerance limits, the quantity of powder fed to the die must be held to within 1% of the optimum quantity.

Flow properties—Composition of the powder mixture is an additional factor. Less pressure is required to produce a part of specified density from bronze powder than from iron powder. For example, a part can be produced from copper powder on a press having considerably lower capacity than would be required to produce the same part from steel powder.

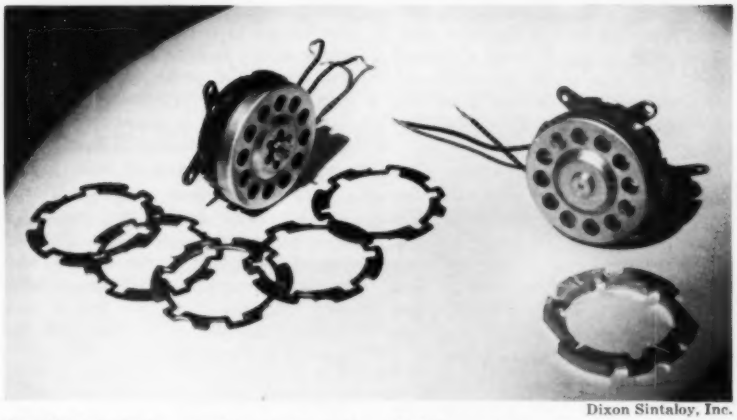
Uses of metal powder parts

Metal powder parts are finding ever increasing use in the automotive, business machine, hardware, aircraft and many other industries. A mere listing of applications would serve no useful purpose. Following, however, are a few brief comments on the uses of the various groups of materials, including reference to several specific applications. Additional applications are illustrated by the photographs.

Ferrous metals

Low density—Low density iron

Nonferrous metal parts are used for

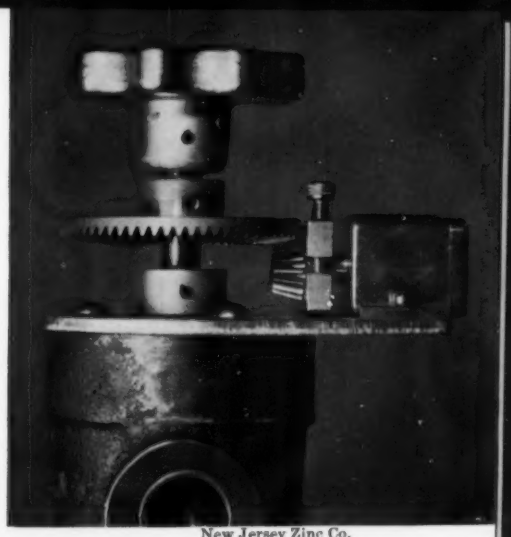


Dixon Sintaloy, Inc.

Shading coil *for electric clock motor. Metal powder part (right) replaced five stampings.*
Material: Copper powder.

General Electric Co.

Jet engine bearing housings *are hot pressed and machined.*
Material: Titanium powder.



New Jersey Zinc Co.

Mating bevel gears *for a piston diaphragm pump are used to link a stroke adjustment device with a pumping rate indicator. The gears were converted from bronze sand castings to brass powder parts at a reduction in cost of 80% for the large one and 65% for the small one.*
Material: 78.5 copper, 20 zinc, 1.5% lead powder.

Keystone Carbon Co.

Bronze retainer and sprocket *are used in automotive clutch for smooth operation and good lubricating properties.*
Material: 90 copper, 10% tin powder.

---

powder parts are used for lightly loaded gears and structural parts in which efficient lubrication can replace hardness and still offer effective wear resistance. These parts have relatively low mechanical properties but are also inexpensive.

Medium density—Medium density iron-copper-carbon parts having a tensile strength range of 60,000 to 73,000 psi (density: 6.2 to 6.6 gm per cu cm) are in use in hundreds of applications. Included are gears for toys, cams, levers, pawls, gears, pinions and roller chain bushings.

The strength and durability of this material can be indicated by the results obtained in testing a small pinion. The pinion, part of a high speed mechanical counting device, was hardened to Rockwell C30. It was subjected to an accelerated acceptance test involving starting, moving one tooth, and stopping at the rate of 1500 rpm. After 20,000,000 rev, it was still functioning with no impact or fatigue cracking.

Another mechanical part is the power roll end plug on an electric typewriter. This plug fastens the shaft to the power roll, and the joint must be sufficiently tight to resist a turning torque of 100 in-lb. This plug was converted from steel or aluminum, the first materials used, to an iron-copper metal powder part, which was given a black oxide finish by steam treatment for mild corrosion resistance. The metal powder part is less expensive than the previous parts and the holding power has been increased to 200 in-lb.

High density—High density iron powder parts (over 6.8 gm per cu cm in density) are particularly

adapted to applications in which 1) a high degree of dimensional accuracy must be maintained, 2) strength requirements are higher than those that can be met with medium density parts, 3) lower porosity is necessary, 4) higher impact strengths and wear resistance are required, and 5) excellent surface finish is required.

Actual applications include parts such as cams, ratchets, pawls, parts to be soldered or copper brazed, parts acting in combination with plastics, and precision gears. Of these, precision gears, in particular, are finding extensive use. It is possible to produce a gear to a high degree of accuracy, uniformity and strength at costs well below those of a comparable gear produced by hobbing and shaving.

Another kind of part is a flint block used in a cigarette lighter. This part is rather complex and requires a soldering operation. Lower density parts were not satisfactory because they absorbed the soldering flux; a poor joint was obtained and corrosion from the retained flux was a problem. The higher density part does not absorb flux and functions satisfactorily.

Infiltrated—Infiltrated iron parts have a wide range of applications that are based generally on two characteristics: 1) infiltration yields high strengths and hardnesses, and 2) infiltration makes it possible to obtain uniform density in parts that are difficult to press to uniform density, such as those with heavy non-uniform sections.

One such part is a pressure rail in a tabulating machine. The rail guides the tabulating card along a shoulder and maintains proper registry while holes are punched in the card. The cards are abrasive and the rail must have high surface hardness. In addition a fine surface finish is required to reduce friction during forward motion of the card. The part was made originally by precision casting and required hand grinding to eliminate surface irregularities, followed by case hardening and satin chromium finishing. To reduce costs, hand grinding was eliminated by converting to a metal powder part made of copper-infiltrated iron which was subsequently case hardened and satin chromium plated.

Pre-alloyed steel—Pre-alloyed steel powders are finding applications in heavy duty parts. For example, a gear for a high pressure hydraulic pump is made from powder having the composition of AISI 4630 steel. It replaces a gear cut from bar stock. Running with a dynamic loading of 2290 lb and a tooth stress of 44,000 psi, the metal powder gear performs as well as the machined gear and is produced at a cost saving of 20%.

Stainless steel—Stainless steel metal powder parts are used for applications requiring noncorrosive properties, particularly in marine, pharmaceutical, chemical, food processing and medical equipment, and aircraft instruments. Applications include cams, levers and intricate parts that are difficult to machine.

Nonferrous metals

Copper—High density copper powder compacts are used for machine parts in which conductivity of 65 to 75% IACS is required and shock resistance is not a factor.

A typical part is a shading coil used to reduce the hum of an a.c. relay that is part of the reset mechanism of a clock. The coil had to be made from a material that was nonmagnetic and had high electrical conductivity. Originally wrought copper was used, but blanking and subsequent machining to close tolerances was expensive. The part was converted to sintered copper (density: 8.3 gm per cu cm) with a substantial reduction in cost. In addition the sintered part is more precise in dimensions than the previous part, making assembly operations easier.

Bronze—Bronze parts are used for applications in which corrosion resistance, stability and high beam loading are factors. Machine improvement often results from the incorporation of the self-lubricating feature that is possible with metal powder parts.

For example, a miniature slip clutch is used to permit a drive motor to continue running when the unit has been driven against a stop. The slip-torque was required to be maintained at 14 to 19 in.-lb through a temperature range of –65 to 175 F. Best results were obtained by using clutch plates made of a sintered bronze friction material bonded to a steel base. Dimensional stability and uniformity of performance were greatly improved with these clutches.

In another case, a gear and ratchet were formerly hobbed out and assembled, from wrought naval brass at a cost of 20¢ per piece. Converted to a bronze powder part, the finished gear, including secondary coining, costs 16¢.

Brass—Brass and nickel silver powder parts are used for structural applications such as gears, cams and spacers. These parts have good machinability and corrosion resistance.

For example, a print wire slug used on a wire printing mechanism was originally made of solid brass. The requirements were uniform weight, close dimensions, corrosion resistance and solderability. Machining of the brass proved difficult and costly. Conversion to a brass powder part (density of 8.1 gm per cu cm) reduced the cost of the part and improved the quality.

Acknowledgment

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International Powder Metallurgy Co.
Johnson Bronze Co.
Keystone Carbon Co.
Kwikset Powdered Metal Products
P. R. Mallory & Co., Inc.
Metal Powder Industries Federation
Midwest Sintered Products
Moraine Products Div., General Motors Corp.
New Jersey Zinc Co.
Powder Alloys Corp.
Powdercraft Corp.
Presmet Corp.
Purolator Products, Inc.
Sintercast Corp. of America
Supermet Div., Globe Industries, Inc.
United States Graphite Co.
Wakefield Bearing Corp.

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SILICONE NEWS

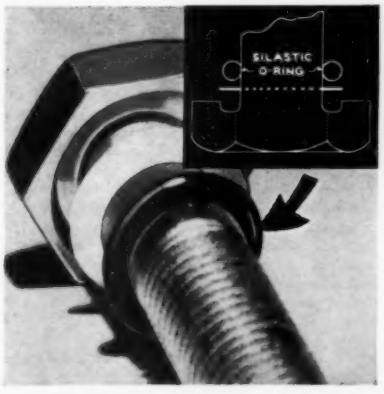
for design and development engineers • No. 61

FASTENERS SEAL FUEL

The new ABSCO fasteners developed by Aero Bolt and Screw Company, Inglewood, California, represent an unusually effective solution to the problem of bolting and sealing airborne fuel tanks to airframes.

A small Silastic® O-ring in a groove under each bolt head makes the ABSCO fasteners liquid-tight. What's more, the O-ring maintains a positive seal over a wide temperature span despite contact with fuel that would quickly ruin ordinary rubber.

A thin Teflon washer between the bolt head and O-ring reduces friction during installation of the fastener and permits the O-ring to flow evenly in all directions under pressure. With maximum shear and tensile properties, the fastener can be used over and over again without lubrication or danger of galling . . . and without need for O-ring replacement. *(Cont. Pg. 2)*



SILICONE COATING ELIMINATES WASTE

"Squeezing the bottle" or shaking it, in futile attempts to drain clinging contents, have been outmoded by silicone coatings. Perhaps this silicone property as applied by Eli Lilly and Company will help you solve a similar problem.

Lilly and Company has used Dow Corning 200 Fluid since 1951 to coat the inside walls of glass vials for aqueous penicillin and for dry antibiotics to which water is added at the time of use. The coating of silicone is simply sprayed into the glass vials and cured to a dry nonoily coating while simultaneously sterilizing the bottle with dry heat.

The photo demonstrates the efficiency of the silicone coating. None of the contents clings to the vial's walls. This means Lilly no longer needs to over-fill the vials to assure physicians a full measure. Another benefit: the silicone treatment makes it easier to stopper the bottles and helps speed processing.

Tasteless, odorless, colorless and physiologically harmless, Dow Corning silicone fluids are widely used in the pharmaceutical industry as coatings for antibiotic vials. They impart a high degree of water repellency that makes possible more complete, cleaner drainage.

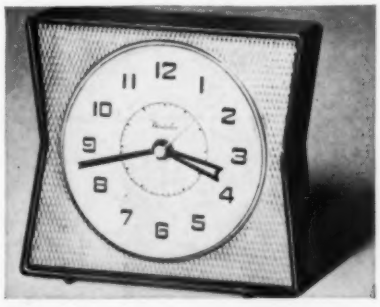
This same coating has also been used to good advantage on blood transfer equipment used in surgery, on clinical and analytical ware, and on glass and ceramic electrical insulators for industrial instruments and electronic units. ***No. 623***

TIMELY TIP ON LUBRICANTS

Specifying a durable silicone lubricant can be that final design touch which assures superior performance and greater customer satisfaction. Westclox Division of General Time Corporation furnishes a nice illustration of this fact.

Six years ago, during their search for better, longer lasting lubricants, Westclox tested and began using Dow Corning silicone lubricants. Today Westclox lubricates all its electric clock motors with Dow Corning 44 Grease. Reason: the silicone lubricant remains effective long after the best organic greases have oxidized or gummed.

Lubricated with nonoxidizing, nongumming silicone grease, Westclox clock motors are always ready for instant "starts" regardless *(Cont. Pg. 2)*



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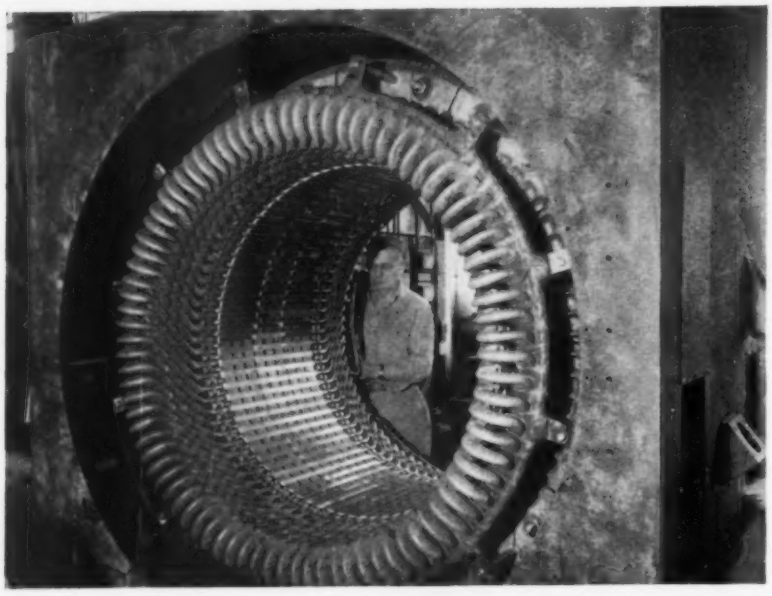

VOLTAGES GOING UP

Combining high temperature resistance with self-protecting qualities, silicone rubber insulation systems are winning increased acceptance for electrical equipment subjected to moisture, heat or thermal cycling. Example, this 11,000 volt, 3,000 hp Allis-Chalmers type AKG sintering-fan drive motor.

Insulation systems made of Silastic®, the Dow Corning silicone rubber, are being designed for increasingly higher voltages. Because of outstanding performance from similar motors designed for voltages ranging from 240 to 6,600, a midwest steel mill has specified an 11,000 volt Allis-Chalmers motor with a Silco-Flex insulation system to drive a sintering-fan.

Vulcanized in place on the motor coils, silicone rubber forms an homogenous insulation jacket that is impervious to moisture and other contaminants. Resilient, it is unaffected by thermal cycling.

When specifying drives, consider all the advantages of silicone insulation. *No. 624*

LUBRICANTS *(Continued)*

of how long they've been in storage. Increasing shelf life helps keep warranty costs low and customer satisfaction high.

In addition to assuring longer, more dependable service, the heat-stable silicone grease keeps gear hum and other motor noises to an absolute minimum regardless of temperature changes. Stored in a reservoir between two bearings, the silicone grease is distributed by rotation of the motor shaft. One pound of Dow Corning 44 Grease lubricates about 1000 clocks!

This lubricant is used with equal effectiveness on metal pinions, plastic drive gears, and brass sleeve bearings of clocks, timers and instruments. *No. 625*

O-RINGS *(Continued)*

ABSCO fasteners are available in all popular head types and sizes. They have passed military requirements including: exposure to aircraft fuels MIL-H-3136, Types I and III at pressures ranging from —14 to plus 100 psi and temperatures varying from —65 to plus 135 F. *No. 626*

new literature and technical data on silicones

Superior Performance is provided by silicone fluids in a wide variety of applications because of their heat stability, oxidation resistance, relatively flat viscosity-temperature slope, good dielectric properties, and many other desirable characteristics. A currently revised data sheet contains new information about the family of Dow Corning silicone fluids that help you specify the product best suited to your application. *No. 627*

Do You Know How silicone resins, rubber, oils and greases are being used to advantage in appliances? A six-page reprint from Electrical Manufacturing relates how extreme temperature resistance properties of silicones have been used in the designs of toasters, refrigerators, irons, portable power tools, percolators and other appliances. *No. 628*

Your Nearest Source of silicone insulating components is listed in a new data sheet. These distributors offer insulating materials which enable you to design electrical equipment with increased life and reliability, increased power per pound. A handy, complete listing of the silicone insulating materials and other Dow Corning Silicones that are available from coast to coast can be yours by writing for ---------- *No. 629*

Adverse Environments are no problem to the designed performance of your equipment if Dow Corning 3 Compound is specified. This silicone dielectric functions as a potting, filling, coating or sealing compound for electrical and mechanical parts. It continues to insulate and lubricate at both high and low temperatures. The unusual stability of 3 Compound, even when exposed to corrosive atmospheres, weathering, most chemicals and oils, is discussed in an illustrated pamphlet. *No. 630*

More Muscles for Tomorrow, a full color-sound movie, lets you see for yourself the benefits of silicone electrical insulation — increased life and reliability, greater overload capacity, and savings in space and weight. Get a folder explaining how to arrange for a showing by circling— *No. 631*

Silicone Molding Compounds are the subject of a four-page comprehensive brochure. Illustrations, tables and graphs demonstrate the outstanding physical and electrical properties that are readily utilized by designers of molded, integral parts for so many mechanisms. *No. 632*

Dow Corning Corporation, Dept. 7016, Midland, Michigan

Please send me: 623 624 625 626 627 628 629 630 631 632

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SILICONE NEWS is published for design and development engineers by

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FILE FACTS

Wrought Cupro-Nickels—A Materials Data Sheet

Type →	Cupro-Nickel, 30%	Cupro-Nickel, 20%	Cupro-Nickel, 10%
COMPOSITION, %	Cu 68.9, Ni 30, Fe 0.5, Mn 0.6	Cu bal, Ni 21, Fe 0.5, Mn 0.6	Cu 88.35, Ni 10, Fe 1.25, Mn 0.4
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.323	0.323	0.323
Melting Temp Range, F	2260-2140	2190-2100	2080-2020
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	17	21	26
Coef of Ther Exp (68-572 F), per °F	9.0×10^{-6}	9.1×10^{-6}	9.3×10^{-6}
Specific Heat, Btu/lb/°F	0.09	0.09	0.09
Electrical Resistivity (68 F), microhm-cm	37	27	15
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	22×10^6	20×10^6	18×10^6
Tensile Strength, 1000 psi			
Annealed[a]	54-60	45-51	44
Half Hard[b]	73	—	—
Hard[b]	80	—	—
Light Drawn[c]	75	80	60
Yield Strength (0.5% ext), 1000 psi			
Annealed[a]	20-22	—	15
Half Hard[b]	68	—	—
Hard[b]	73	—	—
Light Drawn[c]	—	75	57
Elongation (in 2 in.), %			
Annealed[a]	40-45	27	40
Half Hard[b]	12	—	—
Hard[b]	6	—	—
Light Drawn[c]	45	40	42
Hardness (Rockwell)			
Annealed[a]	B37-50	—	B10
Half Hard[b]	B80	—	—
Hard[b]	B85	—	—
Light Drawn[c]	B85	B81	B72
Creep Strength (0.001%/1000 hr), 1000 psi			
At 300 F	24	> 25	> 30
At 500 F	16	17	11
FABRICATING PROPERTIES			
Cold Workability	Good	Good	Good
Hot Workability	Good	Good	Good
Hot Working Temp, F	1700-1900	1650-1850	1550-1750
Annealing Temp, F	1200-1500	1200-1500	1100-1500
Machinability Index[d]	20	20	20
Joining			
Soft Soldering	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Excellent
Metal Arc Welding	Excellent	Excellent	Good
Gas Shielded Arc Welding	Excellent	Excellent	Excellent
Resistance Welding	Excellent	Excellent	Good
Oxyacetylene Welding	Fair	Fair	Fair
Carbon Arc Welding	Not recommended	Not recommended	Not recommended
CORROSION RESISTANCE	Resistant to attack by high velocity sea water, fresh water, steam; sulfuric, phosphoric and mild organic acids; ammonia and ammoniacal compounds, chlorides, sulfates, nitrates		
AVAILABLE FORMS	Plate, rod, strip, tube, wire		
USES	Condenser tubes and plates, heat exchanger tubes, salt water piping, evaporator tubes, process equipment, distillation tubes. ASME code permits use of Cupro-Nickel, 30% in heat exchangers and unfired pressure vessels up to 700 F		

[a]Properties of annealed materials vary with grain size. [b]Strip. [c]Tube. [d]Based on free-cutting brass = 100.

For more information, circle No. 512

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For more information, turn to Reader Service card, circle No. 516

Edited by
John A. Mock

Boiled in oil: *These two o-rings were the same size when immersed in boiling jet fuel. After immersion, the dark nitrile silicone rubber ring maintained its size and shape, whereas the light conventional silicone rubber ring swelled to nearly twice its original size.*

Strength and elasticity *of nitrile silicone rubber is not adversely affected after heat aging in oven.*

First of a new series of silicone rubbers . . .

Nitrile Silicone Compounds Are Heat, Oil Resistant

■ Two nitrile silicone rubber compounds, described as heat, oil and solvent resistant materials, are now available in evaluation quantities. One compound, a 60-durometer stock, is priced at $12 per lb; the other, a 70-durometer rubber, is priced at about $15 per lb. An 80-durometer rubber is expected to be available for evaluation later this spring.

Nitrile silicone rubber, announced last fall by the Silicone Products Dept., General Electric Co., Waterford, N. Y. (see M/DE, Oct '58, p 139), is described as a material that has the oil resistance of nitrile rubber plus the heat resistance of silicones.

Characteristics and typical applications of the three rubbers are described below. Properties are given in an accompanying table.

60-durometer

GE believes its 60-durometer stock, NSR-X5602, will have the widest application of any of the nitrile silicone rubbers being introduced this year. The material is a relatively low modulus stock, suitable for such aircraft and missile applications as seals, boots, bellows, sleeves, diaphragms and shock mounts. It is intended for intermittent contact with high swell fluids or for continuous immersion in milder fluids.

The compound has been designed particularly for fabrication by extrusion, but can also be molded and calendered. Curing is achieved by normal silicone rubber curing

cycles. Typical press schedules would be 5 to 10 min at 280 to 300 F using benzoyl peroxide as the curing agent, or 250 to 280 F using bis (2,4-dichlorobenzoyl) peroxide as the curing agent. Vulcanization in steam may be carried out in 5 to 10 min at 40 to 80 psi. A short, low temperature oven cure is recommended for obtaining good stress-strain properties, whereas a long, high temperature cure is recommended for good compression set properties.

70-durometer

The 70-durometer compound, NSR-X8701, is designed for applications requiring outstanding high temperature oil resistance. It will be suitable for such molded parts as o-rings, gaskets and oil seals.

80-durometer

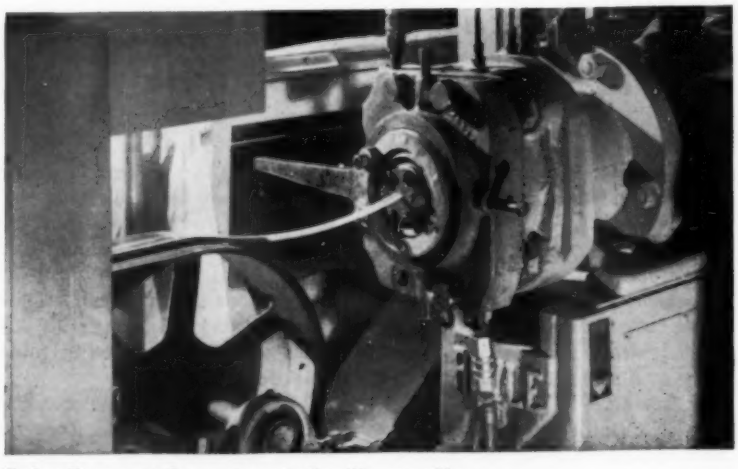
The third nitrile silicone rubber to be introduced by GE this spring is an 80-durometer rubber with intermediate resistance to high temperature fluids. Called NSR-X4803, the material is designed especially for oil seals used in automotive transmissions. The material is also suitable for o-rings, gaskets and similar molded, extruded and calendered parts that may be used in intermittent contact with high swell fluids or in continuous contact with milder fluids.

***Typical parts** that can be made of GE's nitrile silicone rubber.*

PROPERTIES OF NITRILE SILICONE RUBBERS

Type →	X5602	X8701	X4803
PHYSICAL PROPERTIES			
Specific Gravity	1.20	1.25	1.40
Density, lb/cu in.	0.043	0.045	0.050
ORIGINAL MECHANICAL PROPERTIES			
Tensile Strength, psi	1000	650	850
Elongation, %	260	125	125
Tear Resistance (Die B), lb/in.	80	50	75
Compression Set (22 hr at 300 F), %	60	45	35
Durometer Hardness	A60	A70	A80
Brittle Point, F	<−120	<−100	<−120
AFTER AGING 70 HR AT 450 F			
Tensile Strength, psi	700	600	700
Elongation, %	180	100	100
Durometer Hardness	A65	A70	A85
AFTER IMMERSION IN ASTM REFERENCE FUEL A[a]			
Volume Change, %	+75	+10	—
Hardness Change, %	−18	−5	—
AFTER IMMERSION IN ASTM REFERENCE FUEL B[a]			
Volume Change, %	+120	+10	+90
Hardness Change, %	−20	−5	−18
AFTER IMMERSION IN JP-4 JET FUEL			
Volume Change, %			
Room Temperature[b]	+75	+10	—
300 F[c]	+100	+17	—
Hardness Change, %			
Room Temperature[b]	−18	−6	—
300 F[c]	−18	−10	—
AFTER IMMERSION IN WATER[d]			
Volume Change, %	+3	—	+3
Hardness Change, %	−7	—	−5
AFTER IMMERSION IN ASTM NO. 1 OIL[c]			
Volume Change, %	+2	+1	+2
Hardness Change, %	−5	−2	−4
AFTER IMMERSION IN ASTM NO. 3 OIL[c]			
Volume Change, %	+22	+3	+21
Hardness Change, %	−18	−5	−14

[a]Aged 168 hr at rm temp. [b]Aged 168 hr. [c]Aged 70 hr. [d]Aged 70 hr at 212 F. [e]Aged 70 hr at 300 F.



***Extruding** a 60-durometer nitrile silicone rubber.*

Large Aluminum Extrusions Eliminate Joining

■ With the development in recent years of larger aluminum extrusion presses (8000 and 12,000 tons), the primary advantages of aluminum extrusions have been extended to include more intricate configurations, greater cross-sectional areas, larger sections and greater lengths. The major advantage, perhaps, is the elimination of welding, riveting or other joining methods in the production of complex assemblies.

One of the companies presently engaged in the production of a wide variety of large extruded aluminum shapes is Harvey Aluminum, Inc., Torrance, Calif. According to Harvey, the large extrusions replace sections now assembled from smaller components, with resultant weight reductions and savings in assembly and parts costs. The accompanying photos indicate some of the applications for which large extrusions are suited.

STANDARD MANUFACTURING LIMITS FOR[a] . . .

HOLLOW SHAPES

Circumscribing Circle Dia, in.[b]	Minimum Thickness (in.)[c] for Alloy . . .		
	3003, 6061, 6062, 6063	2014, 6066	2024, 7001, 7075, 7178
10-12	0.125	0.156	0.187
13-15	0.140	0.171	0.250
16-18	0.156	0.187	0.375
19-24	0.171	0.250	0.437

SOLID SHAPES

Circumscribing Circle Dia, in.[b]	Minimum Thickness (in.)[c] for Alloy . . .		
	3003, 6061, 6062, 6063	2014, 6066	2024, 7001, 7075, 7178
10-12	0.109	0.125	0.156
13-15	0.125	0.156	0.187
16-18	0.140	0.171	0.250
19-24	0.156	0.187	0.375

PANELS[d]

Extruded Form	Circumscribing Circle Dia (flat), in.[b]
—	9-25½
^	14-36
⊓	18-51
◇	21-57
⬡	21-60

TUBE[e]

Alloy	Minimum Thickness, in.[c]
3003, 6061, 6062, 6063	0.093-0.153
2014, 6066	0.125-0.184
2024, 7071, 7075, 7178	0.156-0.345

[a] The following limitations apply to corner and fillet radii for alloys 2024, 7001, 7075 and 7178: alloy 2024: minimum corner and fillet radii of 0.010 in.; alloys 7001, 7075 and 7178: minimum corner radii of 0.031 in. for sections having a thickness greater than 0.124 in. Minimum corner radii of 0.016 in. for sections having a thickness less than 0.125 in. The minimum fillet radii is 0.031 in.

[b] The diameter of the smallest circle that will completely enclose the shape.

[c] Applicable to mean thickness if unequal plus and minus tolerances are specified.

[d] Minimum thickness, in.: alloys 3003, 6061, 6062, 6063—0.062-0.182; alloys 2014, 6066—0.072-0.213; alloys 2024, 7001, 7075, 7178—0.094-0.0600.

[e] Inside diameter ranges from 7-25 in.

Size and shapes

According to Harvey, the following shapes can be produced in large aluminum extrusions: tube; integrally stiffened panels; stepped extrusions; structural sections such as I-beams, H-beams, channels, angles, tees and zees; bar and rod; and semi-hollow, hollow, solid and special configurations.

The softer alloys are more easily extruded into complicated shapes than are the high strength alloys because of the relatively low extrusion pressures required. Tube can be extruded with i.d.'s up to 25 in. and with varying wall thicknesses, depending on the length and alloy.

Integrally stiffened panels, in which the skin and stiffening elements are extruded in one piece, are available either flat or in V or U forms which can be flattened to produce parts wider than the diameter of the extrusion die. Tubular extrusions can also be flattened to make wider sections. According to Harvey, 60-in. wide panels have been extruded.

Stepped extrusions, produced by interrupting the initial extruding process and then changing the die, usually combine two or more sections in a single length. Stock left on the section for machining is negligible compared to the time and amount of metal that would otherwise be lost if the entire shape had to be milled out.

Structural aluminum shapes, which are comparable to the largest fabricated steel sections, are generally used wherever rolled steel shapes are used, with these advantages: better strength-to-weight ratio, custom design, reduced fabricating costs and maximum resistance to corrosion. Structural shapes are available from Harvey in heat treated lengths of up to 80 ft. A typical aluminum I-beam section can be extruded with a web of 24 in.

Available alloys

The following aluminum alloys, both cold worked and heat treated, are presently being extruded on the large presses: EC, 3003, 2014, 2024, 6061, 6062, 6063, 6066, 7001, 7075, 7079 and 7178. Cold worked alloys are usually supplied in the annealed or as-fabricated temper. Heat treatable alloys are furnished in several tempers covering a range of mechanical properties from the annealed, or "O" temper, to the heat treated and aged T6 temper.

Applications

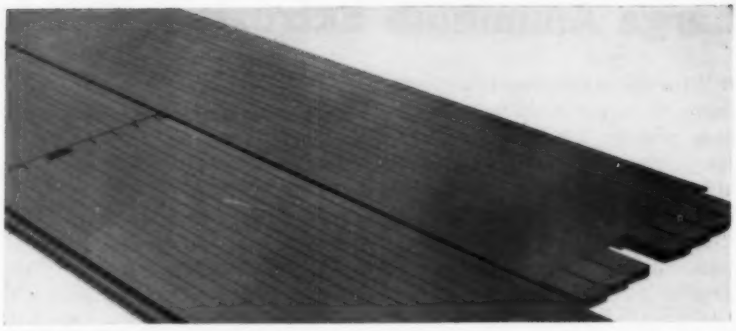
Current applications include: missile body sections, truck trailer floors and doors, deck cooling panels for aircraft carriers, airframe structural members, portable landing mats, curtain wall components, structural building shapes, diving board sections,

atomic energy, highway signs, parts for missile components, and materials handling equipment.

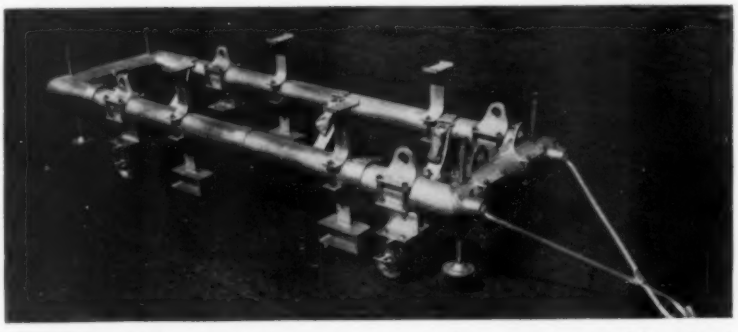
Design factors

The factors governing the design of large aluminum extrusions are the same as those for conventional extrusions, except that limits have been broadened. The maximum cross-sectional dimension for large extrusions is limited by a circumscribing circle approximately 32 in. in dia (the smallest circle that will completely enclose the shape). Standard manufacturing limits for various shapes are given in the accompanying tables. Tolerances published by the Aluminum Assn. are considered standard by Harvey. However, for many shapes, closer tolerances are possible.

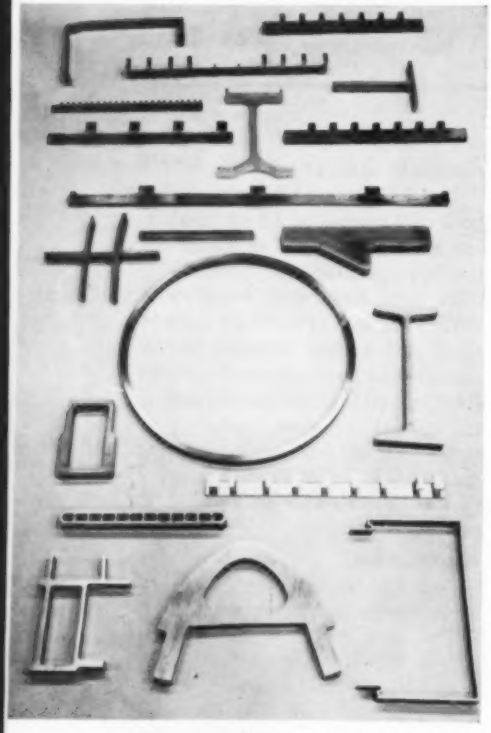
Properties of the large extrusions are the same as those obtainable with conventional extrusions, and the parts are supplied to the same specifications. The relationship between size and



Aluminum landing mat *is integrally stiffened with provision for joining in both horizontal directions.*



Aluminum skid *made of large extrusions, replaces previous model made of steel. Unlike the original, the skid is now universally adaptable, lighter and considerably less expensive.*



Cross sections *of typical large aluminum extrusions.*

MORE WHAT'S NEW IN MATERIALS

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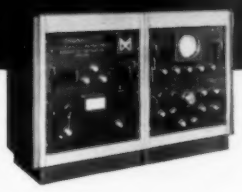
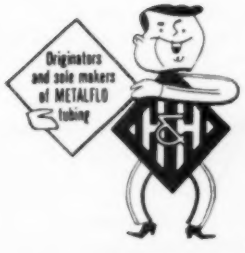


The bright, clean, uniform color of H & H tubing, the burr-free ends tells of quality you can *see*. But today scientific instruments like the Magnaflux unit pictured at the left, watch for tubing imperfections the human eye *can't* see. So if you want tubing that's free of all inclusions, laminations, laps and slivers, tubing that's free of any wavy conditions inside or out, it will pay you to always remember you can *depend* on H & H.



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What's new IN MATERIALS

***Structural shapes** are available in lengths up to 80 ft.*

allowable section thickness is a function of the forming factor of the shape, the extrusion ratio, the length of the section and the alloy used. The larger extrusions provide these advantages: greater section modulus and higher moment of inertia. In addition, thinner shapes, unbalanced cross sections, and channels with a depth-to-width ratio of 6 to 1 and higher are possible.

New Plastics Resins, Laminates Announced at SPI Meeting

■ Engineering data on three new plastics materials—a new family of polyester resins, a hydrocarbon thermosetting resin and a heat resistant polyester-glass laminate—were presented at the 14th Annual Technical Conference of the Reinforced Plastics Div., Society of the Plastics Industry, Inc. held Feb 3-5 in Chicago.

1. New polyester resins

The new polyester resins have high flexural strength at elevated temperatures and good creep resistance when wet. In fact, creep resistance of the resins approaches that of a heat resistant epoxy resin (see Fig 1).

The resins make use of isophthalic acid in place of the *o*-phthalic anhydride used in conventional rigid unsaturated polyester formulations. Resins discussed at the meeting were developed by California Research Corp., Richmond, Calif. Information on the properties and fabrication of the materials was given by G. G. Johnson, A. L. Meader and C. F. Perizzolo of California Research Corp.

Tests were performed on a resin containing isophthalic acid, propylene glycol and maleic anhydride copolymerized with styrene. Variations of this formulation were tested to determine the effect of crosslinking on the properties of the resin.

Creep resistance: Data in Fig 1 show that creep resistance of a polyester resin having a 1:2 isophthalic/maleic anhydride ratio is comparable to that of a heat resistant epoxy resin. Isophthalic polyester resins having lesser proportions of maleic anhydride have progressively greater creep. A conventional polyester resin made with a 1:1 *o*-phthalic/maleic anhydride ratio fails completely in a few minutes, as shown in Fig 1.

Fig 2 shows creep resistance of an isophthalic polyester resin at various temperatures under wet condi-

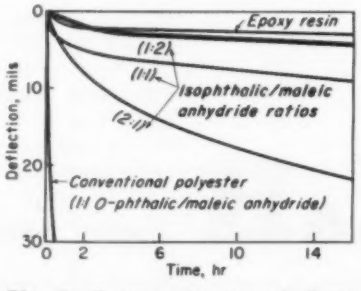

***Fig 1**—Creep resistance of three isophthalic polyester resins compared to creep resistance of a heat resistant epoxy resin and a conventional polyester resin under wet conditions.*

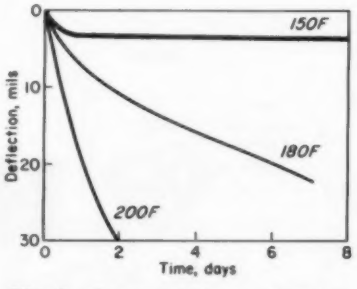

***Fig 2**—Creep resistance of an isophthalic polyester resin at various temperatures under wet conditions. The resin reaches an equilibrium deflection at 150 F.*

For more information, circle No. 513 ➤

For the savings in tool costs made by Hydroforming

Col. Herman E. Lacy calls this his

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Col. H. E. Lacy is owner of Hydroforming Company of America, Inc., Chicago. As one of the nation's leading suppliers of custom Hydroformed parts, he is exceptionally well qualified to talk on tool cost savings. "The unique Hydroform technique," says Col. Lacy, "has saved our customers *millions of dollars of tool costs.* Further, Hydroforming combines extreme precision in deep drawing, with versatility that gives designers unequalled freedom. Better drawn parts, in fewer operations, at lower costs, can be yours by Hydroforming."

The photo above shows five Cincinnati Hydroform® machines in operation at this custom deep drawing shop—an 8″, a 12″, two 19″ and a 23″ size machine. The company's capacity for producing larger Hydroformed parts will soon be increased by the addition of a Cincinnati 32″ Hydroform.

To determine if Cincinnati Hydroform machines can produce savings for your manufacturing program, call in a Meta-Dynamics Division field engineer.

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Machines for Metal Forming and Heat Treating

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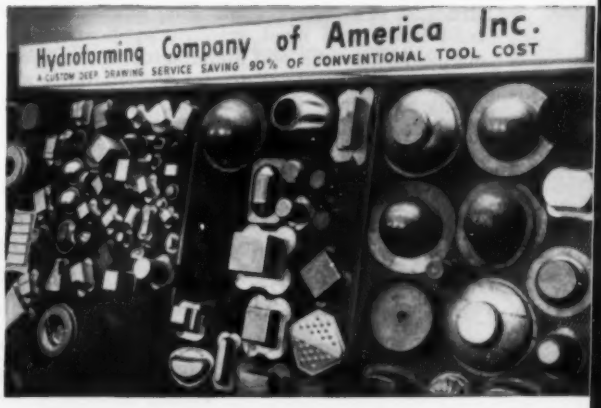
Cincinnati 9, Ohio, U.S.A.

CINCINNATI



This photo of a display panel at Hydroforming Company of America, Inc., shows the wide range of Hydroformed part size, gage and complexity of shape produced by this firm.

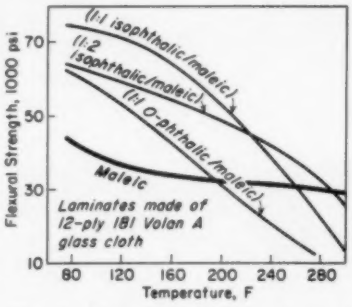


***Fig 3**—How heat affects flexural strength of various unsaturated isophthalic polyester laminates.*

tions. The resin reaches an equilibrium deflection at 150 F and has a steady creep at 180 F. The difference in the curves at 150 and 180 F indicates a second-order transition temperature somewhere between these two temperatures. Unpublished data indicate the transition temperature is probably near 175 F.

Heat distortion temperature of the polyester resin (1:2 isophthalic/maleic anhydride) is 270 F (ASTM D648-56), or approximately 100° F higher than the temperature at which the resin will resist creep.

Johnson, Meader and Perizzolo say this difference in temperature shows the danger of relying on heat distortion points when designing plastics structures for load bearing service at high temperatures. Creep curves as determined by testing under actual conditions of exposure provide a much more reliable guide.

Flexural strength: The isophthalic polyester resins have flexural strengths comparable to those of epoxy resins at temperatures below 212 F.

Reinforcing the resins with glass fibers improves not only flexural strength and modulus, but also heat resistance. Fig 3 shows how heat affects flexural strength of various unsaturated polyester laminates. Resins with a high maleic anhydride content have the best high temperature properties.

2. Hydrocarbon thermosetting resin

The new hydrocarbon thermosetting resin for reinforced plastics is now in pilot plant production. Major benefits of the material are its low

density, exceptional resistance to water, good chemical resistance and excellent electrical properties.

The resin, presently designated as C-oil, is a liquid copolymer of butadiene and styrene in the approximate weight ratio of 80:20. Copolymerization is carried out in such a manner that the butadiene reacts predominantly as a mono-olefin, resulting in vinyl groups attached to the polymer chains. It was developed by Esso Research & Engineering Co., Chemicals Research Div., P. O. Box 51, Linden, N. J. Information on properties and fabrication of the resin was given by H. Clark and B. M. Vanderbilt of Esso.

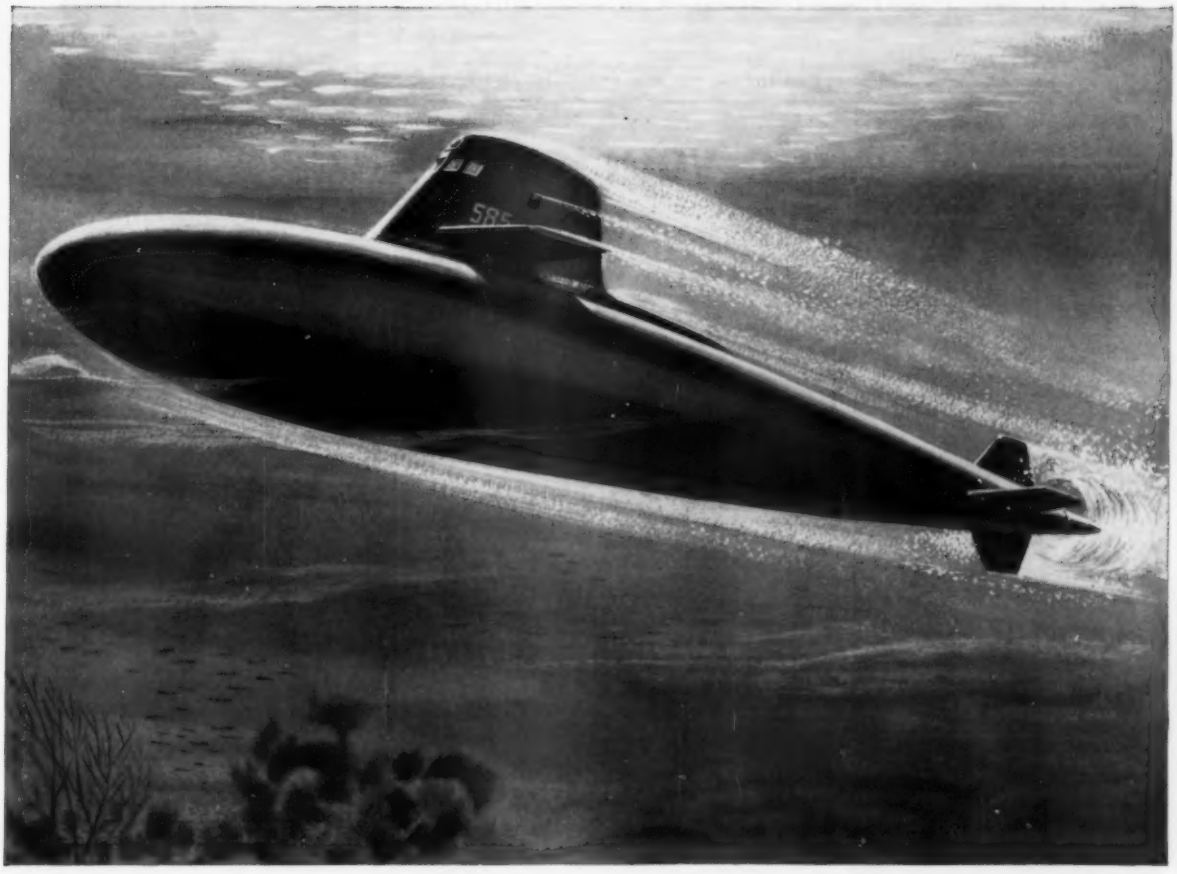
Reinforcing agents—Although inorganic and organic fibers in general can be used for reinforcing C-oil, most work has been done with 181 glass fabric. A vinyl silane finish on heat cleaned glass produces a laminate with good wetting properties and good mechanical properties. C-oil laminates made with unfinished glass have poor wetting properties, are opaque, and have poor physical properties when cured.

Glass roving and matting having the usual polyvinyl acetate and/or polyester sizings do not give optimum results with C-oil because the resin is incompatible with the sizings.

The silane ester apparently becomes attached to the glass by an exchange type of reaction with the (OH) groups on the glass surface, liberating the alcohol from the silane ester.

Unfilled castings—An unfilled casting requires some pressure during molding to obtain a crack and bubble-free solid. Castings ⅛ in. thick reach "full cure" after molding under 100-200 psi pressure for 15 min at 285 F followed by 45 min aging at 300 F. A lower cure may be used for applications where full resin strength is not needed. Unfilled resins cured at lower temperatures are flexible, have little or no water absorption, and have electrical properties similar to those of fully cured resins. Properties of a molded unfilled resin are given in Table 1.

B-stage prepreg—C-oil-glass laminates are particularly suited for fabrication in the B-stage or par-



Sandusky cylinders help the Skipjack CRUISE, DIVE, STEER, BREATHE and FIGHT!

Centrifugally cast cylinders by Sandusky play vital roles in the U. S. Navy's newest atomic-powered submarine, No. 585 *Skipjack*, as components of the nuclear propulsion system, the steering and diving systems, the torpedo firing mechanism, and radar and induction mast assemblies.

The *Skipjack* is the prototype of a new series of seven submarines all with blimp-shaped hulls for greater underwater speed. Her design and materials specifications were laid down by the U. S. Navy and her builder, The Electric Boat Division of General Dynamics Corporation, who chose Sandusky Centrifugal Castings to do more than ten jobs in structural, mechanical, pneumatic, and hydraulic applications.

All of these components – centrifugally cast of heat and corrosion-resistant stainless steels, high-strength carbon steels, Monels, and bronzes–provided the *Skipjack's* designers with the required mechanical and physical properties at the lowest cost.

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TABLE 1—PROPERTIES OF UNFILLED C-OIL RESIN

PHYSICAL PROPERTIES	
Appearance	Transparent
Density, lb/cu in.	1.02
Refractive Index	1.563
Water Absorption (24 hr), %	0.02
MECHANICAL PROPERTIES	
Flexural Strength, psi	11,250
Flexural Modulus, 10^5 psi	3.5
Heat Dist Temp, F	233
ELECTRICAL PROPERTIES	
Volume Resistivity, ohm-cm	6.6×10^{16}
Dielectric Constant	
10^3 Cps	2.53
10^6 Cps	2.53
Power Factor	
10^3 Cps	0.0011
10^6 Cps	0.0014
Arc Resistance, sec	78
Dielectric Strength, v/mil	808
Surface Resistivity, ohm	
50% RH	31×10^{12}
96% RH	25×10^{12}

tially cured condition. In this condition, laminates are stable, are easy to handle, have low mold shrinkage, and can be cured on fast mold cycles. Properties of a C-oil-glass laminate are given in Table 2.

3. Polyester-glass cloth

The polyester-resin-preimpregnated glass cloth has good high temperature properties, good flame resistance, excellent electrical properties, good chemical resistance and long shelf life (7 months). The polyester-glass cloth, designated Stampreg P1 and described as a B-stage or partially cured material, was developed by Standard Insulation Co., Inc., 74 Paterson Ave., East Rutherford, N. J. Information on properties and fabrication of the new material was given by H. J. Ried and Norman

TABLE 2—PROPERTIES OF C-OIL-GLASS LAMINATE[a]

Cure	Durometer Hardness	Appearance	Flex Str, psi
350 F			
2 Min	D77-80	Clear	20,300
5 Min	D81-85	Clear	26,000
400 F			
2 Min	D81-83	Moderate cracks	20,700
5 Min	D84-86	Moderate cracks	21,900

[a]Laminate contains about 35% glass.

In this 48 page handbook you'll find useful engineering and fabricating data including practical examples showing where, when and how Van Huffel Roller Die, Cold Formed Metal Shapes simplify design, increase production and reduce costs. It includes information on material selection, machine operations on shapes, fabrication methods, tolerances for roll forming, and dozens of interesting illustrated ideas that have taken shape in metal.

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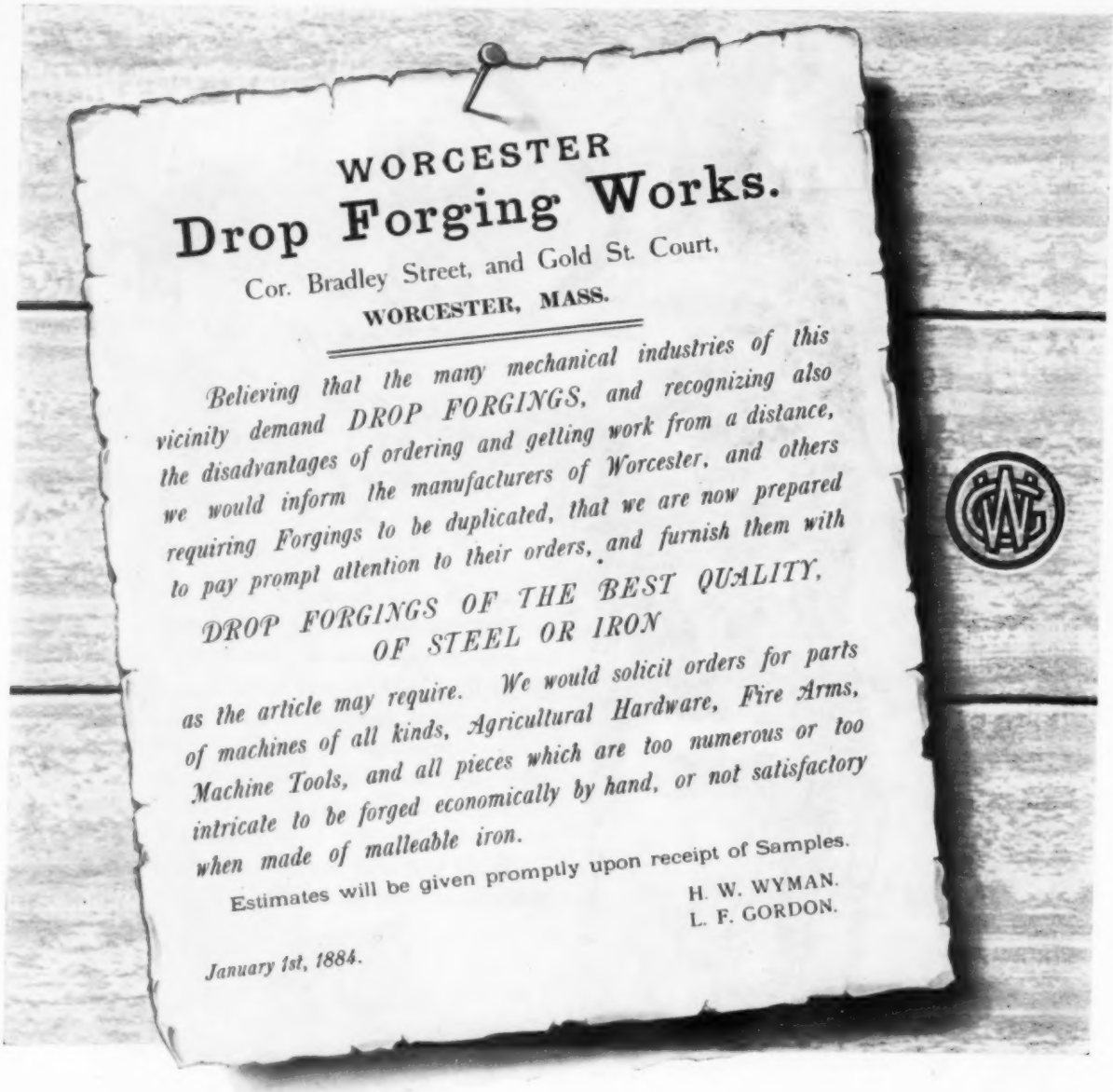

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L. F. GORDON.

January 1st, 1884.

Reproduced above is the formal announcement made January 1, 1884 of the partnership formed a few weeks previously in November of 1883 and known as the Worcester Drop Forging Works, later to be incorporated as Wyman & Gordon.

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What's new IN MATERIALS

TABLE 3—PROPERTIES OF STANPREG P1

PHYSICAL PROPERTIES	
Specific Gravity	1.938
Resin Content, %	36.6
Water Absorption, %	0.11
Flammability, in./min	Self-extinguishing
ORIGINAL MECHANICAL PROPERTIES	
Ten Str, psi	54,400
Compr Str (edgewise), psi	56,900
Flex Str (flatwise), psi	76,500
Rockwell Hardness	M119
AFTER IMMERSION IN WATER[a]	
Ten Str, psi	58,100
Compr Str (edgewise), psi	52,100
Flex Str (flatwise), psi	73,600
AFTER HEAT AGING[b]	
Flex Str, psi	
160 F	70,900
250 F	70,180
350 F	48,180
400 F	34,838
450 F	29,520
AFTER IMMERSION IN HYDRAULIC OIL	
Flex Str, psi	74,240
Weight Change, %	0.052
Thickness Change, %	None
AFTER IMMERSION IN ETHYLENE GLYCOL	
Flex Str, psi	75,960
Weight Change, %	0.056
Thickness Change, %	None
AFTER IMMERSION IN HYDROCARBON FLUID	
Flex Str, psi	74,520
Weight Change, %	None
Thickness Change, %	None
ELECTRICAL PROPERTIES	
Dielectric Constant (1 mc)	
Dry	4.02
Wet	4.17
Loss Tangent (1 mc)	
Dry	0.009
Wet	0.014

[a]Aged 30 days. [b]Aged ½ hr.

Cassie.

Ried and Cassie described Stampreg P1 as a general purpose reinforced plastics material for both military and commercial applications. Laminates made of Stampreg P1 have retained approximately 50% of their

Next month abstracts of five additional papers will be presented. These include: 1) behavior of reinforced plastics at very high temperatures; 2) effects of stress concentrations on the strength of reinforced plastics laminates; 3) synthetic fiber fabrics and batts as reinforcements for polyester resins; 4) reinforced low density moldings; and 5) shear effects in fiberglass-reinforced plastics laminates.

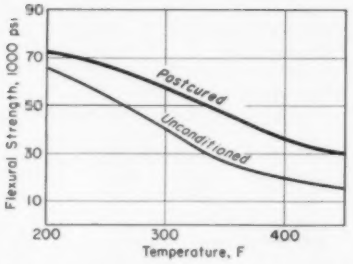

***Fig 4**—How heat affects flexural strength of postcured and unconditioned isophthalic polyester-glass laminates.*

original strengths at temperatures up to 400 F after aging 200 hr. Physical, mechanical and electrical properties of a Stampreg polyester-glass laminate are given in Table 3.

Fig 4 shows how heat affects the flexural strength of unconditioned and postcured polyester-glass laminates.

Rigid Foamed Metals Are Light in Weight

Foamed metal that resembles a petrified sponge and is nine times lighter than solid metal has been developed by General Electric Co., Flight Propulsion Laboratory, Cincinnati, Ohio. The new foamed metal, called F-alloy, can be molded into practically any desired shape during the foaming process, and can be machined with conventional tools. To date, nickel, copper and cast iron have been foamed. (For information on foamed aluminum, see M/DE, Nov. '57, p 200.)

Potential applications

Tests at the Flight Propulsion Laboratory have demonstrated the value of foamed metals for use as rubbing seals in high temperature areas of jet engines. Other potential jet engine applications include labyrinth seals, high temperature filters, thermal insulators and transpiration cooling devices. Foamed metal has also been found to be an ideal filler material for sandwich-type metal structures.

Many other uses have been conceived for foamed metals outside the

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What's new IN MATERIALS

***Rigid foamed material** is so porous that cigarette smoke passes through it easily.*

jet engine field. For example, foamed copper may find its way into many large electrical installations. The heat generated by electricity passing through solid copper limits the amount of electricity it can carry. However, foamed copper has the same capacity for electrical conductivity per unit of weight as solid copper. The natural cooling action of foamed copper seems to increase its capacity for carrying electricity.

Fluorocarbons Made Bondable by Radiation

Fluorocarbon plastics parts can be made bondable and dyeable by using a new radiation grafting technique that changes the surface characteristics of the plastic being treated. Unmodified fluorocarbon plastics (TFE, Kel-F, etc.) have wax-like surfaces to which almost nothing will adhere. In the radiation technique, one form of plastic is molecularly attached or grafted to the surface of another. The result is not a coating, but a change in the surface characteristics of the plastic being treated.

The radiation grafting technique was perfected by Radiation Applications, Inc., 370 Lexington Ave., New York City, and is now being used on a limited basis to treat fluorocarbon tape, wire insulation, valve seats and gaskets.

Munroe F. Pofcher, president of the company, says the radiation technique has the following advantages over conventional heat treat-

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KANIGEN makes possible the use of inexpensive basis metals for tankage, valves and piping, storage and reaction vessels. It is particularly satisfactory for austinitic stainless steels when stress corrosion cracking is a problem.

Complex shapes that vary in size from a 20,000 gallon tank car to a tiny control valve can be given a uniform coating of the required thickness with Kanigen. Coating may be done by rack, jig or barrel methods.

You can get **KANIGEN** chemical nickel alloy plating from General American at Sharon, Pa.; East Chicago, Ind.; or Compton, Cal., and from licensees in many cities. For detailed information or technical advice, call or write. You'll find... *IT PAYS TO PLAN WITH GENERAL AMERICAN.*

KANIGEN is a trademark which identifies chemical nickel coating by General American Transportation Corporation and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.

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***Workman** removes fluorocarbon plastics parts from a cobalt-60 radiation source.*

ing and metallic sodium immersion techniques: 1) it is the only commercial method known that can make a fluorocarbon plastic bondable without altering its color; and 2) it reduces the cost of treating fluorocarbons by as much as 25%. The radiation technique does not radically alter properties of fluorocarbon plastics, except that tensile strength is increased by about 20% and elongation is decreased from 500 to 200%.

Eventually, the company hopes to use radiation to dissipate static electricity in fluorocarbon plastics, to put a cementable surface on polyester film, and to make polyethylene film permanently anti-static.

Vinyl Wrinkle Finishes Are Tough, Durable

The development of what are claimed to be the first vinyl wrinkle finishes has been announced by Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17. The finishes, based on plastisols, organosols and solutions, are said to be durable and to have good chemical resistance.

Plastisol coatings: Carbide recommends vinyl plastisols be used for obtaining wrinkle coatings of maximum thickness. The particular advantages of vinyl plastisols for wrinkle finishes are: 1) freedom from objectionable volatiles, thus eliminating fire hazards; 2) application at 100% solids for maximum film build; 3) excellent film flexi-

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It is non-solvent, non-alkaline and not an emulsion. It has the desirable penetrating properties of both alkali and solvent yet affords complete protection for the surface finish.

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bility; and 4) tough films.

Organosol coatings: Where the use of volatiles is not objectionable and lower viscosity coatings are desired, organosols may be used in place of plastisols for wrinkle finishes. The chief advantage of organosols are: 1) a greater range of film hardness is possible; 2) handling with conventional spray equipment is easier due to lower viscosity of the coating; 3) lower viscosities permit higher pigmentation and a greater range of possible modifiers; 4) thinner films may be produced than are possible with plastisols; and 5) film flexibility and hardness may be varied over a considerable range.

Solution coatings: The major advantage of solution vinyl wrinkle finishes is that coatings may be baked at a lower temperature than is possible with either plastisols or organosols.

Silicone Laminate for Electrical Parts

Dilecto GB-89S is the name given to a new economy-grade silicone laminate introduced recently by Continental-Diamond Fibre Corp., New-

PROPERTIES OF DILECTO GB-89S

PHYSICAL PROPERTIES	
Water Absorption (24-hr immersion), %	0.15
Density	1.80
MECHANICAL PROPERTIES	
Tensile Strength, psi	
Lengthwise	30,000
Crosswise	20,000
Flexural Strength, psi	
Lengthwise	30,000
Crosswise	28,000
Compressive Strength (flatwise), psi	55,000
Flammability, sec	
Ignition Time	212
Running Time	105
Flammability Index	3.38
Rockwell Hardness	M83
ELECTRICAL PROPERTIES	
Dielectric Strength	60
Dissipation Factor (1 mc)	0.0025
Dielectric Constant (1 mc)	4.0
Insulation Resistance (cond C96/35/90), megohms	5000
Surface Resistance (cond C96/35/90), megohms	2000
Arc Resistance, sec	200

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- **plastic that foils vandals**
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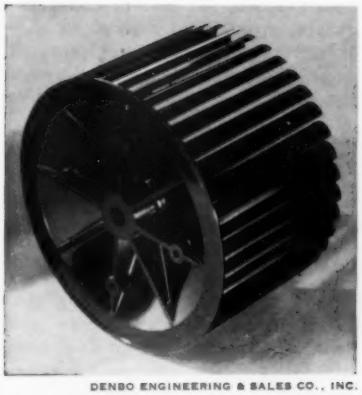

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A. The ring that you'd expect to see steadying the blades at the far end.

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You don't make blower wheels? All right. We're happy if we have implanted an idea for *anything* you might construct better or more cheaply with a Durez general-purpose phenolic. For still more ideas on where and how to apply these durable, versatile materials, send in the coupon requesting Bulletin D400.

Vandalproof

Big-city switchblade artists used to rip the stuffings out of upholstered bus seats—to the tune of $100,000 a year in damage.

Then city transit authorities ordered 330 new buses with glass-reinforced plastic seats like the ones you see here. Made with tough, fire-retardant Hetron® polyester, these seats can't be slashed, defy destruction.

They cost less to make than upholstered seats. And the passengers like them better—voted overwhelmingly in favor of them in rider reaction tests.

Now transit officials plan to replace *all* the city's buses with vehicles featuring these vandalproof seats.

AMERICAN SEATING COMPANY

Where can *you* see a market for strong reinforced-plastic shapes that retard fire? There's a whole family of Hetron resins to help you do your visualizing. Hetron is *inherently* self-extinguishing—gives fire retardance with no loss of mechanical strength. Heat resistance, moisture resistance, electrical properties of Hetron laminates and premix-molded shapes are outstanding.

To get a better idea of what you can do with these fire-retardant resins, use the coupon to request the complete Hetron data file.

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If you want to know how you might add a pinch of permanence to a product, mail us the coupon. The bulletin you'll receive tells how 12 industries are doing this very thing with Durez resins.

For more information on the Durez materials mentioned above, check here:

- ☐ 8-page Bulletin D400 lists properties, uses, design advantages of general-purpose Durez phenolics and other thermosetting materials.
- ☐ Data file (50A) on Hetron fire-retardant polyester resins.
- ☐ Industrial applications of Durez phenolic resins (12-page bulletin).

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What's new IN MATERIALS

ark, Del. The laminate is made from a coarse weave, continuous filament, glass fabric bonded with a silicone resin. It is particularly suited for such electrical applications as terminal, mounting and spacer blocks for motors and generators; spacers for separating coils in dry type transformers; terminal boards and switch bases in electronic equipment and dielectric heaters; and power devices such as switchgear and electric welders.

Cadmium-Coated Steel Does Not Embrittle

A new method for applying cadmium coatings in a vacuum now makes it possible to protect high strength steels against corrosion without danger of hydrogen embrittlement. The coating method, developed by NRC Equipment Corp., 160 Charlemont St., Newton Highlands 61, Mass., is said to compare favorably with electroplating in production costs and quality of coatings.

In vacuum coating, no hydrogen is present either from acids or from the air, and embrittlement of coated parts cannot occur. In electroplating, acids in the plating bath cause the surface layer of high strength steels to absorb hydrogen.

The vacuum process is expected to find use in the aircraft industry for coating parts made of high strength steels which tend to become embrittled when electroplated. Such parts include landing gear structures, control parts and threaded fasteners. The process is also ex-

Coated parts, *a mild steel bolt (bottom) and a notched 4340 steel specimen (top), as they look after 96-hr salt spray test.*

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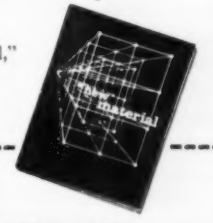

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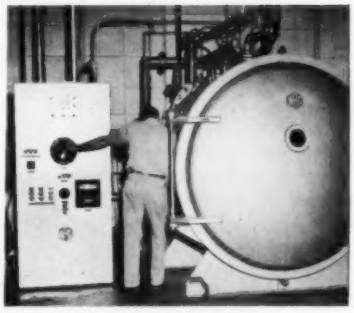
What's new IN MATERIALS



***Cadmium coatings** are vacuum deposited on high strength steels in equipment similar to that shown here.*

pected to be used for coating automotive parts, industrial machinery and other equipment.

How parts are coated

In the cadmium coating technique, which is related in principle to the vacuum metallizing process, hole-free, homogeneous cadmium coatings in thicknesses up to 0.001 in. or more are applied to metal parts by vaporizing cadmium inside an evacuated chamber and condensing it on the parts. This is done by hanging a small cadmium staple on tungsten wires which are then heated to incandescence by electrical current. The heat from the tungsten filaments is transferred to the cadmium staples which evaporate and then condense on the parts.

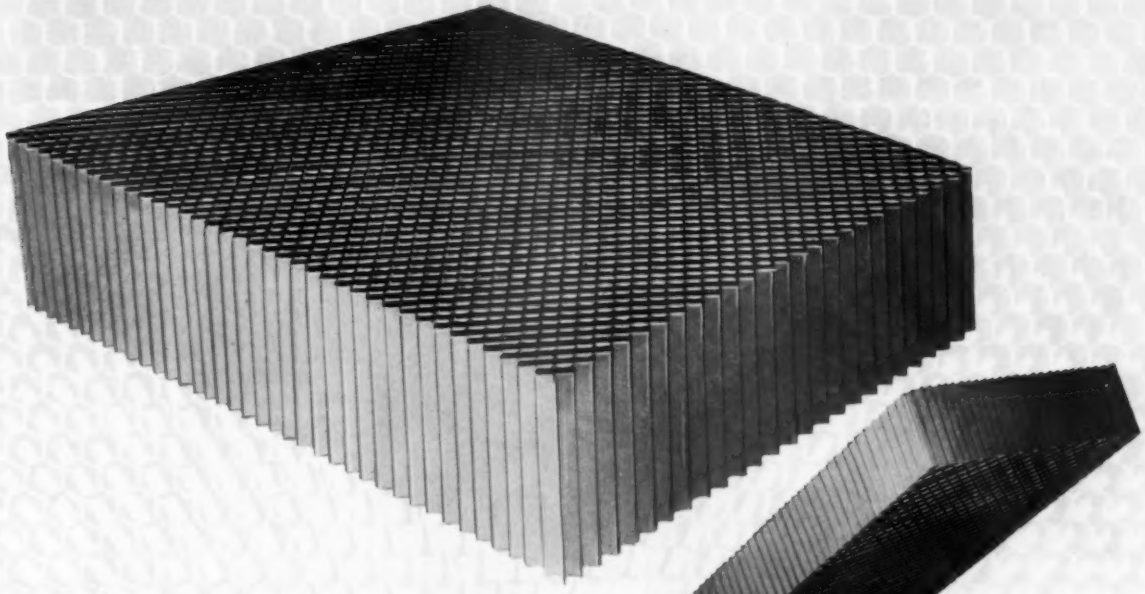
Clear Acrylic Resin Is Heat Resistant

A new heat resistant, transparent acrylic type thermoplastic resin has been developed by J. T. Baker Chemical Co., Phillipsburg, N. J. The resin, called PL-11, is presently being field evaluated. Cost of the resin will probably be around 80 to 90¢ per lb at initial production and much lower once production gets going.

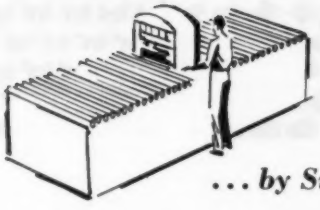
Properties and uses

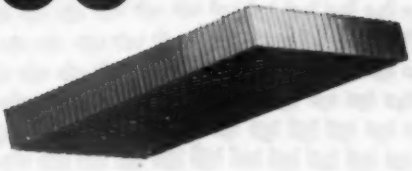
Once available, the resin will probably find use in automobiles, aircraft, optical devices, appliances, lighting fixtures and instrument panels.

The thermoplastic is similar in mechanical and optical properties to polymethyl methacrylate, but has a



PROGRESS





... by Swedlow in the manufacture of high temperature welded honeycomb core is a major factor in the production and performance of advanced aircraft and missiles.

Swedlow's new precision automatic machines mean thicker, wider and longer blankets of honeycomb core with the added features of close tolerances, increased production and improved deliveries.

To Manufacturers: Swedlow welded honeycomb core means new possibilities in design with the advantages of high strength and rigidity-to-weight ratios, excellent thermal and fatigue resistance, acoustical insulation, vibration damping and corrosion resistance.

To Fabricators: Swedlow welded honeycomb core means improvements in the arts of machining, brazing and welding of panels. Swedlow's quality control assures clean, uncontaminated honeycomb core with uniform node welds, close tolerances, uniform cell sizes and shapes, optimum node widths, flatness and bond strengths.

From Swedlow's progressive research programs in methods and materials will come improved higher temperature welded honeycomb cores. Expert technical service is available from Swedlow's applications advisory group.

For full information, contact the Swedlow plant nearest you, or write for technical bulletin "High Temperature Welded Honeycomb Core." Please refer to Dept. 18.

SWEDLOW Inc.

Formerly Swedlow Plastics Company

Los Angeles 22, California
Youngstown 9, Ohio

What's new IN MATERIALS

PROPERTIES OF PL-11

PHYSICAL PROPERTIES	
Specific Gravity	1.17
Water Absorption (24 hr), %	0.20
Flammability, in./min	1.7
Odor	None
Taste	None
Light Stability	Very good
MECHANICAL PROPERTIES	
Impact Strength (notched Izod), ft-lb/in.	0.3
Tensile Strength, psi	9000
Elongation, %	2
Flexural Strength, psi	
77 F	15,000
160 F	9500
220 F	5000
Flexural Modulus, psi	
77 F	480,000
100 F	335,000
220 F	215,000
Heat Dist Temp (264 psi), F	250
Rockwell Hardness	M103
Machining Qualities	Very good
ELECTRICAL PROPERTIES	
Dielectric Constant	
10^3 Cps	3.00
10^6 Cps	3.03
Dielectric Strength, v/mil	475
Dissipation Factor	
10^3 Cps	0.028
10^6 Cps	0.011

heat distortion point about 50°F higher (250 F at 264 psi). According to the developer, parts made of the material may be immersed in boiling water for days without affecting their water-white transparency.

PL-11 resin is resistant to dilute solutions of most acids and alkalis, and to petroleum oils, aliphatic hydrocarbons and alcohols. It is not resistant to oxidizing acids, ketones, esters, and aromatic and halogenated hydrocarbons.

Vinyl-Coated Steel Is Wear Resistant

A new vinyl-metal product with good scuff and abrasion resistance has been introduced by United States Steel Corp., 525 William Penn Place, Pittsburgh 30. The company says the product is a vinyl-coated sheet steel, not a vinyl-metal laminate.

U. S. Steel produces the material by a continuous process in which liquid vinyl plastisols are bonded and cured directly to sheet steel. The

When you want ALUMINUM SHEET...

CALL REVERE!

You can be sure, when you specify or order from Revere, that you will get not only fine metal but fine service, including Revere's cost-saving Technical Advisory Service if desired. Revere—now an integrated producer of aluminum—can supply you from large modern sheet mills in Baltimore, Md., and Chicago, Ill.

In addition to aluminum coiled and flat sheet, circles and blanks, both plain and embossed, Revere can furnish aluminum seamless drawn, welded and extruded tube; extruded shapes; forgings; foil; and primary aluminum pig and ingot.

It pays to do business with the most dependable sources of supply—such as Revere, which has been fabricating fine non-ferrous metals for more than 150 years.

Revere Aluminum Coiled and Flat Sheet
up to 48" wide and up to .125" thick

Alloys			
1100	3003	5005	5052
1145	3004	5050	5357

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

For more information, turn to Reader Service Card, circle No. 422

What's new IN MATERIALS

Typical parts *that can be formed from textured vinyl-coated steel.*

vinyl-coated steel is available in seven textures, and custom textures can be supplied on an exclusive basis.

A typical price for an 18-gage sheet steel coated with 0.010 in. of vinyl would be 35¢ per sq ft in quantities of 20,000 sq ft. This is about 2½ times the price of steel.

Results of a market evaluation program indicate the material has potential use for automobile interiors, appliance cabinets, architectural products, office fixtures, railroad car and bus interiors, and furniture.

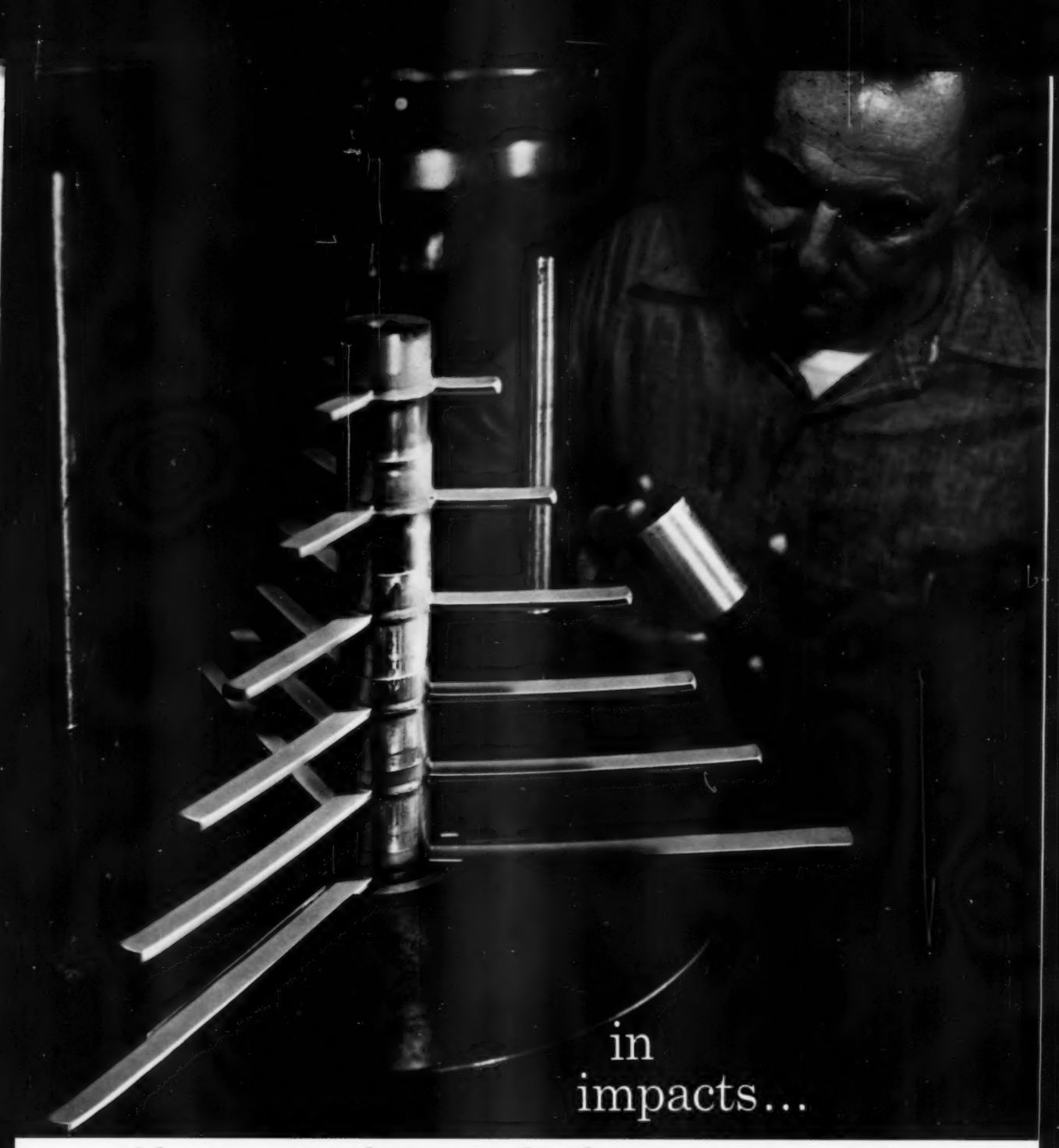
Properties

Heat resistance—Vinyl-coated steel can withstand continuous exposure to temperatures up to 160 F without loss of color, texture or adhesion. The product withstands a temperature of 212 F for 2 days, softens appreciably at 350 F, and chars at temperatures above 400 F. It will not, however, support combustion.

Moisture resistance—Boiling water has no effect on vinyl-coated steel

Inspecting *a coil of vinyl-coated steel that has just been textured. The new product is produced in both sheets and coils in gages from 18 to 28 and in widths up to 52 in.*

For more information, circle No. 528 ➤



Alcoa puts the metal where you want it

This "tree" represents six stages in the growth of an Alcoa® Impact. Actually the flow of metal occurs at a blink of the eye, but we've shown it in stages, outside the die for the sake of clarity. Furthermore, the finished piece (which you see on the bottom) has no practical use. It has, however, practical value. It starts the imagination fiddling with a host of design problems that involve the joining of several spokes to a central hub. For instance, it's not hard to imagine the spoke frame for an automobile steering wheel or horn ring sitting in its place. If that idea has you going, bear in mind that we can make round, oval, square and irregular parts the same way. Finished parts in many instances have greater *strength* than forgings —with *tolerances* down to plus or minus 0.005 in.—with a smooth, corrosion-resistant finish of about 125 microinches. A clear case of putting the metal where *you* want it.

In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where *you* want it. A call to Alcoa can mean fewer rejects or ingenious design solutions. Start now; write for Alcoa Up-To-Daters, a file of design tips on Alcoa Engineered Products. Aluminum Company of America, 928 Alcoa Building, Pittsburgh 19, Pa.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM

Alcoa puts the metal where you want it — in castings, forgings, extrusions, screw machine parts and impacts.

For Exciting Drama Watch
"Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

How Keystone QUALIFIES

as the leading independent producer of POWDER METAL PARTS

(over 150,000,000 of them annually)

We're told, often enough, that "There's a difference in dealing with Keystone."

In looking over some of the reasons-why, it occurs to us that because we were pioneers in powder metallurgy, perhaps we do have a special kind of perspective about our work. Over and beyond the essentials of a sound organization and production facilities to meet your requirements for almost any quantity of parts . . . on time, and at low cost . . . we have qualifications that are inseparable from the Keystone way of doing things.

One of them is *alert interest* in your problems (we learn more that way). Another: *creative approach* to your designs—which keeps us flexible. And one of special importance: *objective evaluation*—if application is unsound, we're frank to say so.

Perhaps we should conclude with *progressiveness.* Facts are, Keystone was first to produce commercially powder metal parts of alloy and stainless steels; first in the field to offer lower-than-commercial tolerance bearings, and first to provide corrosion-resistant finishes on iron powder parts.

For these and other reasons, a great many people turn to Keystone for the powder metal parts their businesses require. It's easily possible that you'd enjoy having us work for you, too. Write, and let's talk it over.

Keystone CARBON COMPANY

ST. MARYS, PA.

POWDERED METAL PARTS DIVISION

after immersion for 5 min.

Stain resistance—Detergents, acid cleaners, nail polish, fruit acids, alcoholic beverages, ink, alkaline cleaners and conventional die lubricants have no effect on vinyl-coated steel. Iodine, lipstick and acetone stain the material.

Fabrication

Welding: Projection, stud, spring-loaded electrode, magnetic force and capacitor discharge welding techniques have been successfully applied to vinyl-coated steel sheets without damaging the vinyl coating.

Forming: The vinyl-metal product can be sheared, slit, punched, lock seamed, stamped, drawn and roll formed without damage to the coating. It can easily withstand elongation of 30%.

Fastening: U. S. Steel says the product can be fastened in practically as many ways as are used for fastening steel. Included are nuts and bolts, sheet metal screws, rivets, spring clips, steel-to-steel adhesives, staples and vinyl-to-vinyl adhesives.

How product is made

U. S. Steel Corp.'s vinyl-coated steel is produced as follows:

1. Cold rolled or galvanized strip is cleaned.
2. Strip is etched by an electrochemical treating process.
3. A thin film of thermosetting adhesive is applied to the strip.
4. Primer is applied to the reverse side of the strip to afford corrosion protection.
5. Adhesive and primer are cured in an oven.
6. A liquid vinyl plastisol is applied to the strip in coatings ranging from 0.008 to 0.020 in. thick and heat cured on the steel to produce a permanent bond.
7. The coated strip is textured while still hot.

Oil-Extended Rubbers

Two new synthetic rubbers extended with 50 parts of oil have been introduced by Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio.

Plioflex 1713 is a non-staining, non-discoloring cold rubber extended with a naphthenic oil. It provides

For more information, circle No. 515

light color characteristics and is designed for use in toys, flooring, sporting goods, heels and soles.

Plioflex 1714C is a staining cold rubber extended with a highly aromatic oil. It is designed for use in tires and mechanical goods.

Rhenium Rod, Wire Withstand 4500 F

Commercial production of wrought rhenium rod, wire and strip will soon be started by Chase Brass & Copper Co., 236 Grand St., Waterbury 91, Conn.

Properties and uses

The metal has a melting point of 5756 F, surpassed only by tungsten and carbon, and, when used in thermocouples, can make possible the measurement and control of temperatures up to 4500 F. Though not a structural metal, rhenium holds great promise as a welding material for molybdenum.

The good electrical properties of the metal should make it suitable for electrical contacts. Tests show that contacts made of rhenium have a life expectancy 20 times greater than any material currently being used in electrical contacts. Rhenium contacts have good resistance to wear, corrosion, arc erosion and pitting.

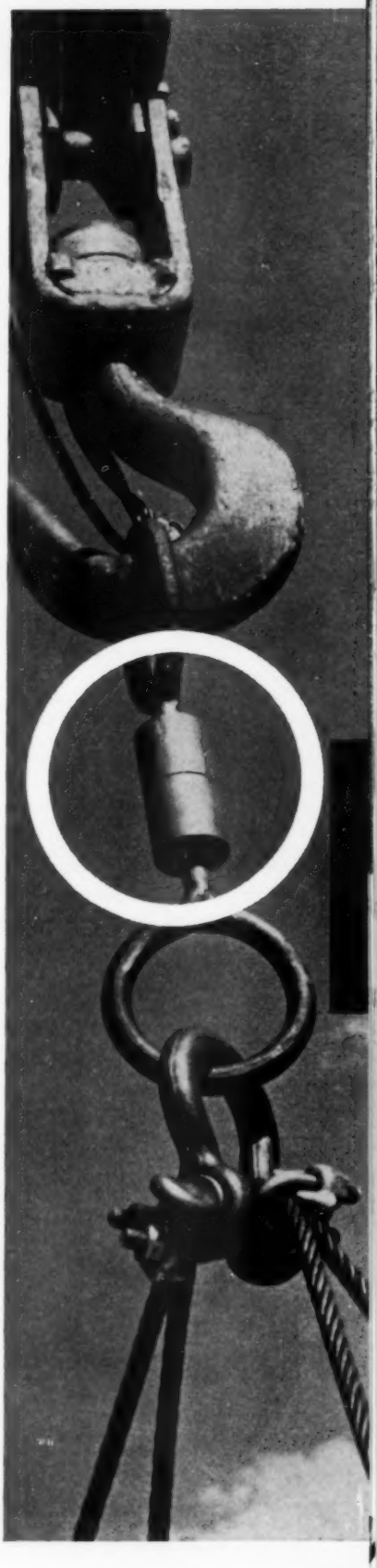
Rhenium metal, because of its good ductility, high purity, high temperature strength and good weldability, should be an excellent material for filaments in electronic vacuum tubes.

How rod, wire, strip are made

Rhenium rod, wire and strip are made by powder metallurgy techniques in which powder is pressed

MECHANICAL PROPERTIES OF RHENIUM

Tensile Strength, psi	
Strip	165,000
Rod	170,000
Wire	165,000
Elongation (in 2 in.), %	
Strip	10
Rod	13
Wire	15
Vickers Hardness	
Strip	270
Rod	285
Wire	250



← 2½ tons held by one drop of new adhesive demonstrates breakthrough in adhesive technology

Eastman 910 Adhesive opens way to new design approaches and faster, more economical assembly-line operations

One drop of Eastman 910 Adhesive is applied to the end surface of a 2-inch diameter steel rod, tapped to receive eye bolt.

← The steel rod is held against the end of a similar steel rod for several seconds. The joined rods are then fitted with eye bolts and placed between a crane hook and lifting harness.

After setting for 30 minutes, the bond formed by one drop of Eastman 910 Adhesive supports a load of 5,000 pounds.

Send for a trial kit. Each trial kit contains approximately ⅛ ounce Eastman 910 Adhesive in a polyethylene bottle with dispensing spout, instruction sheet and material for evaluation tests. Price . . . $5

Here is a ready-to-use adhesive that sets almost instantly and develops high strength bonds in a matter of minutes. Moreover, it requires no heat, pressure or catalyst . . . and forms bonds with virtually all materials.

Eastman 910 Adhesive comes close to meeting the requirements of an ideal industrial adhesive. It is solving assembly problems for manufacturers of jet aircraft . . . trophies and jewelry . . . fountain pens . . . radiation measuring instruments . . . electronic components . . . rubber swimming masks . . . metal and plastic hand tools . . . and steel-backed rubber printing plates. In many cases this remarkable adhesive makes possible innovations in design previously considered impractical or impossible.

Look at its many features and see how you can take advantage of the unusual combination of properties available in this fast-setting, high-strength adhesive.

- SETS FAST–Makes unbreakable rubber-rubber bond in 30 seconds; bonds steel-steel firmly in 3 minutes.
- VERSATILE–Joins virtually any combination of wood, glass, metal, rubber, cork, leather, paper, porcelain, gems, minerals and most plastics.
- HIGH STRENGTH–Steel-steel bonds show shear strengths up to 3,800 psi, tensile strengths up to 4,600 psi, after 24 hours at room temperature.
- EASY TO USE–Thorough cleaning is the only surface preparation necessary. It is ready to use as supplied, no catalyst or mixing necessary.
- CURES AT ROOM TEMPERATURE–No heat is required to initiate or accelerate setting. Setting begins immediately upon spreading into a thin film.
- CONTACT PRESSURE SUFFICIENT–No pressure is required beyond that necessary to maintain good contact between surfaces.
- LOW SHRINKAGE–There is virtually no shrinkage on setting as neither solvent nor heat is used.
- GOES FAR–One-pound package contains sufficient adhesive for 13- to 14,000 one-drop applications to smooth, non-porous surfaces.

Eastman 910 Adhesive offers new opportunities for engineers, experimenters and fabricators in both design and production. It is ideal for applications where extreme speed of setting is desirable . . . or where design requirements involve small joining surfaces, complex mechanical fasteners or heat-sensitive assemblies. Eastman 910 Adhesive saves countless man-hours of production time.

To find out what it can do for you, send five dollars for a trial kit.

Developed by Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Co., Kingsport, Tenn., Eastman 910 Adhesive is distributed world-wide by Eastman Chemical Products, Inc., Armstrong Cork Company and by their sales offices and agents.

Eastman 910 ADHESIVE

Send your order for the five dollar trial kit of Eastman 910 Adhesive to: Eastman Chemical Products, Inc., Chemicals Division, Dept. E-4, Kingsport, Tenn., or to: Armstrong Cork Company, Industrial Adhesives Division, 9104 Dunbar St., Lancaster, Pa.

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Chicago
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Cleveland
Detroit
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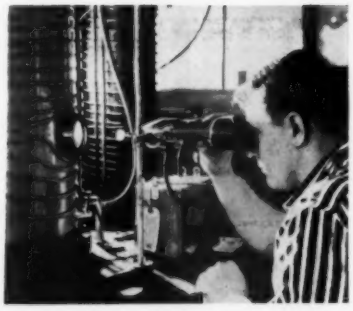


***Measuring** sintering temperature of rhenium bar: temperature must be maintained at 5000 F to produce a high density bar.*

into bars, sintered under vacuum, then sintered in a hydrogen atmosphere at 5000 F. After sintering, bars are cold rolled into rod and wire ranging from 0.003 to 0.175 in. in dia, and into strip 0.002 in. thick. The metal is annealed frequently between reductions to insure quality.

Glass Flake Fillers Make Plastics Tough

Glass flake laminates are stronger; stiffer; have higher glass contents (up to 85%); and have better weather, moisture and vapor resistance than other glass-plastics laminates. Glass flake laminates also have equal strengths in all directions and are truly isotropic in the plane of the laminate.

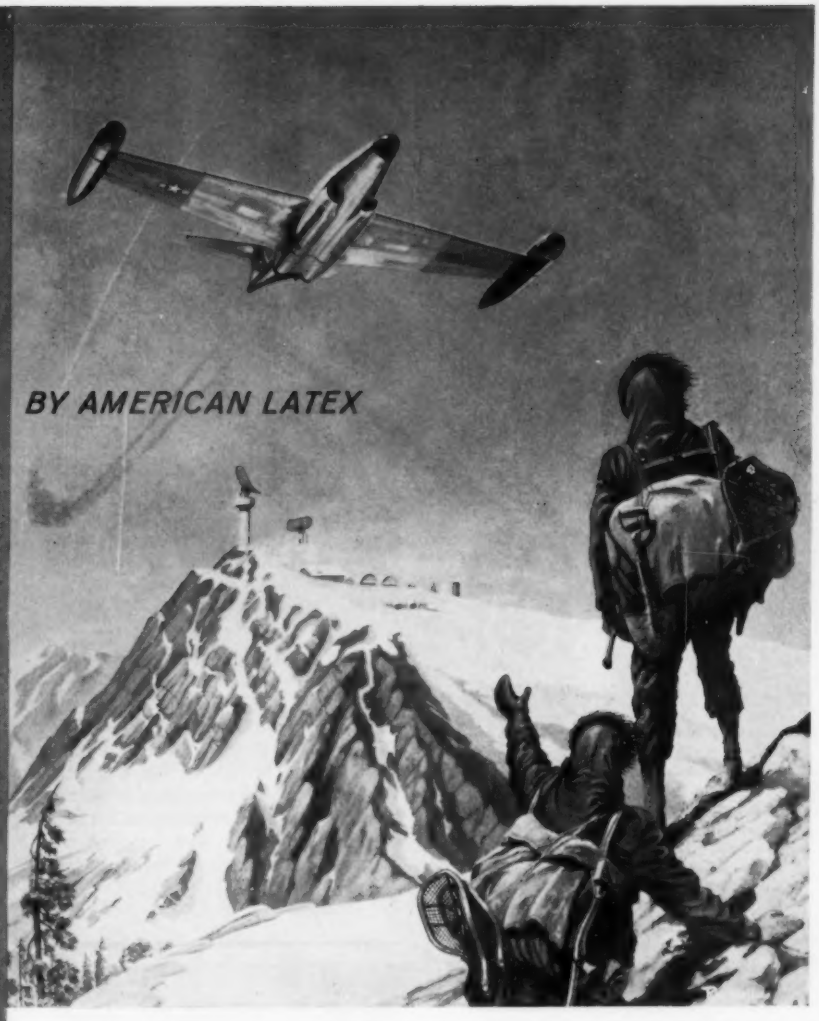
These are the opinions of A. M. Shibley and P. H. Rotschild, of Picatinny Arsenal, who presented a paper on glass flake plastics laminates at a symposium on structural plastics. The symposium, held last fall in Dayton, Ohio, was jointly sponsored by Wright Air Development Center and the University of Dayton.

Fabrication

In their paper Shibley and Rotschild outlined work being done by the Army Ordnance Corps in developing and fabricating high strength glass flake laminates. Examples of such laminates are glass flake-polyester optical parts having flexural strengths up to 30,000 psi and glass flake-polycarbonate (Lex-

PERIMETER PROTECTION

WITH
STABOND
PROTECTIVE COATINGS



BY AMERICAN LATEX

ASK FOR ***STABOND T-200***
the 2 component coating system that withstands most surface damaging elements.

CURING TIME
½ to 1 hour under elevated temperatures of 175° to 200°F; 3 to 7 days at room temperatures from 70° to 80°F.

TACK FREE
in 10 to 20 minutes at room temperatures from 70° to 80°F.

POT LIFE
(working life) 24 to 36 hours at room temperature from 70° to 80°F.

STANDARD COLORS
Black, grey and white. Other colors can be processed to meet your specific color requirements.

PACKAGED
as a 2 component system. Provides long term storage stability under normal conditions.

STABOND — ADHESIVES COATINGS SEALANTS

Any perimeter of any product can be permanently protected with STABOND, particularly when corrosive effects must be stopped! Here is the dependable protective hypolon coating for all surfaces against oxidation, weathering, moisture, oil, gasoline, jet fuels, acids and alkalies. Thoroughly tested under many conditions, STABOND coatings are now applied to hundreds of manufactured products where contact and exposure demand maximum protection.

STABOND T-200 is *the* versatile hypolon coating for...

- Rubber products
- Rubberized cloth
- Flexible fuel cells
- Hatch & door cells
- Rubberized shock mounts
- Crash pad cushioning
- Rubber hose and couplings
- Interior head liners
- Rubber gaskets
- Marine & industrial cable
- Metal storage tanks
- Tank liners
- Outdoor electric conduit
- Exposed components
- Arctic clothing & equipment
- Exposed structures
- Hospital equipment
- Food processing equipment

WRITE TODAY: Your investigation may uncover an entirely new dimension in the practical application of STABOND.

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The Freedlander Research and Development Center at Hawthorne, California is available to research and/or provide exacting information for new STABOND *applications.*

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For more information, turn to Reader Service card, circle No. 440

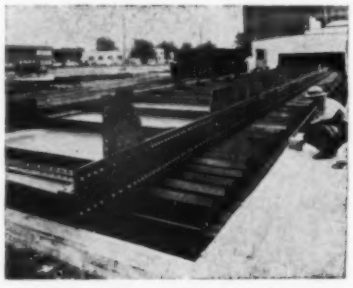
What's new IN MATERIALS

PROPERTIES OF GLASS FLAKE-POLYCARBONATE LAMINATE

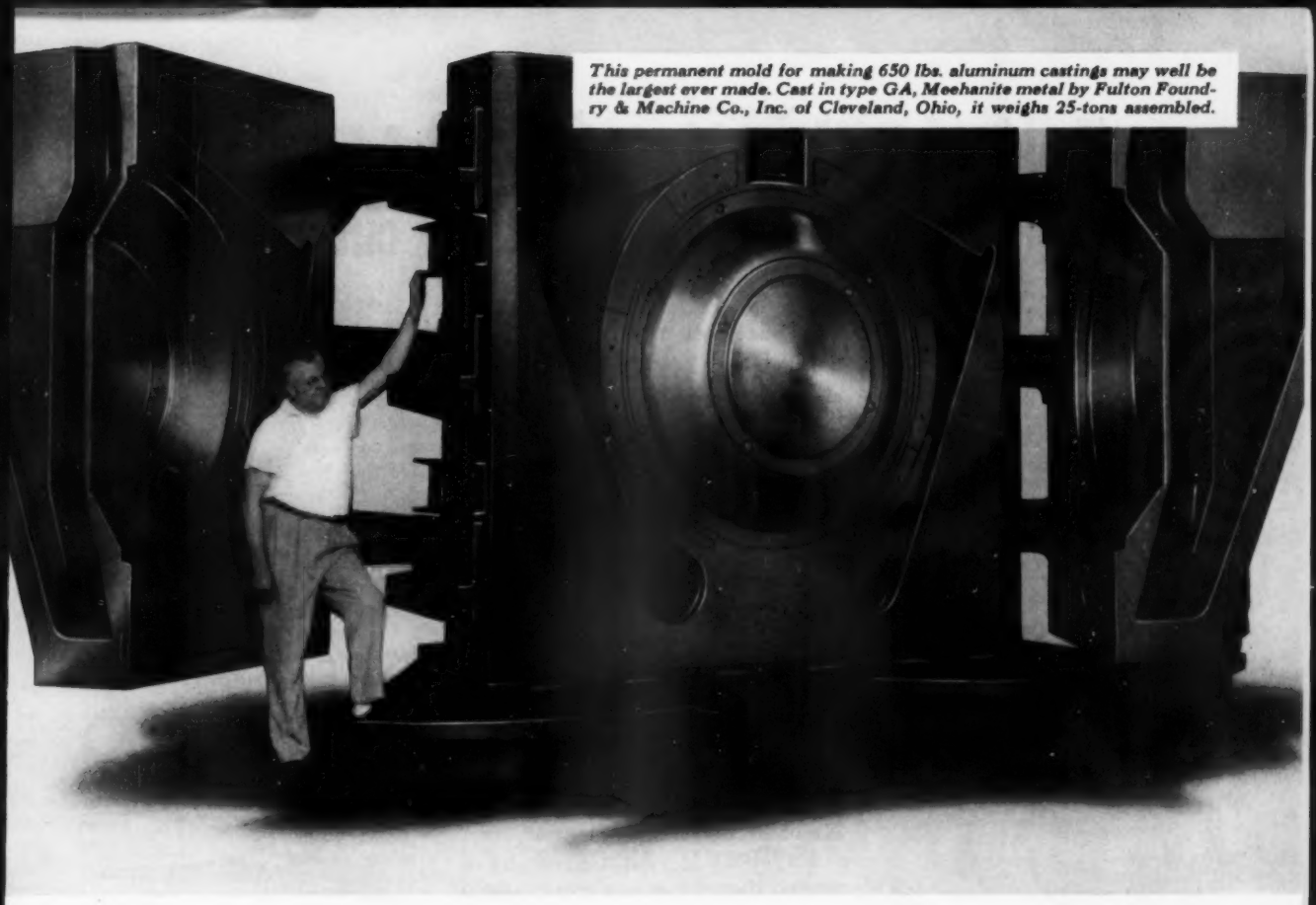
Resin Content, %	30
Ult Tensile Strength, psi	25,000
Tensile Modulus, 1000 psi	5.0
Flexural Strength, psi	36,000
Flexural Modulus, 1000 psi	4.3
Notched Izod Impact Strength, ft-lb/in.	.2
Heat Distortion Temp, F	330
Dielectric Strength, v/mil	800

an) parts having flexural strengths up to 36,000 psi. Properties of a glass flake-polycarbonate laminate are given in an accompanying table.

The biggest problem with flake laminates seems to be the method of fabrication. The present laboratory method is unwieldy and time consuming: essentially it is equivalent to a hand lay-up method. Laminate properties are entirely dependent on the technique for treating the flake and the subsequent molding operation. Flakes must be uniformly coated with resin and be free of voids or air pockets. In molding, the



Painting large steel shapes—The picture above shows a recently completed conveyorized spray unit capable of prime coating over 200 tons of structural steel shapes a day. Now in operation at R. C. Mahon Co., 6565 E. 8 Mile Rd., Detroit 34, the unit is designed to handle structural steel shapes from 1 to 200 ft long. It is capable of supporting 1200 lb of steel per lineal ft, and can process a 52-ton girder, 130 ft long, in about 30 min—said to be about 2½ hr less time than for conventional stationary methods. Mahon engineers say any steel truss less than 15 ft high can be put through the prime spraying operation with ease.



This permanent mold for making 650 lbs. aluminum castings may well be the largest ever made. Cast in type GA, Meehanite metal by Fulton Foundry & Machine Co., Inc. of Cleveland, Ohio, it weighs 25-tons assembled.

Meehanite permanent molds offer resistance to heat checking and distortion from thermal shock.

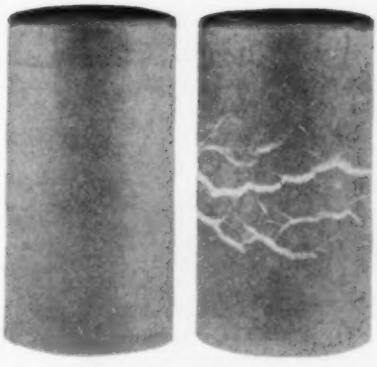
Premature cracking or disintegration of surface is a serious problem to the users of permanent molds. Severe service conditions demand the selection of a metal with a dense close-grained structure which maintains dimensional accuracy and resists the disastrous effects of thermal shock.

Meehanite metal has the ability to more than meet these requirements and is used extensively for permanent molds in the production of both ferrous and non ferrous castings, glass, plastics and other materials. The huge mold illustrated is proof of the confidence placed in Meehanite.®

The chief advantage of a Meehanite mold is consistent uniformity of structure throughout the casting. Meehanite's dense, stabilized structure resists thermal shock, insures freedom from distortion and dimensional changes. Easily machined, it provides the smooth, highly polished surface so essential to good finish and long production life.

Meehanite molds can be cast closely to shape to reduce machining operations. Also, they may be heat treated or flame hardened where high hardness is required.

Write for free literature: Bulletin 23 — "Meehanite® — The Metal For Permanent Molds."



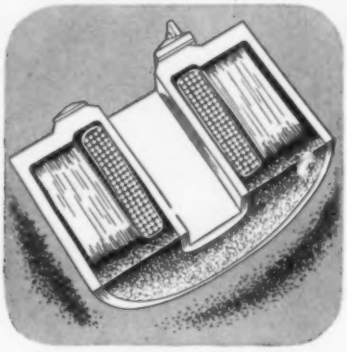
The block on the right reveals what happens when an ordinary permanent mold material is suddenly heated and cooled. The Meehanite block on the left, given same test, shows complete freedom from surface cracking.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

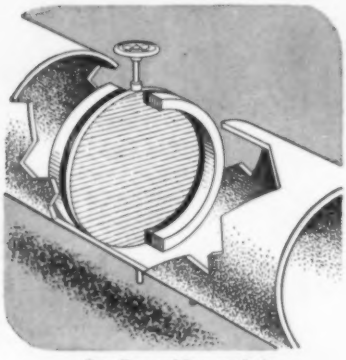
MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

Tailored R/M *Ray-BOND*® Adhesives speed and simplify your production, cut your costs



Sealing hundreds of wires with an R/M encapsulating compound.



Bonding rubber seals to rotating water gate valves.

Resin-treated paper bonded to metal saves weight in this honeycomb.

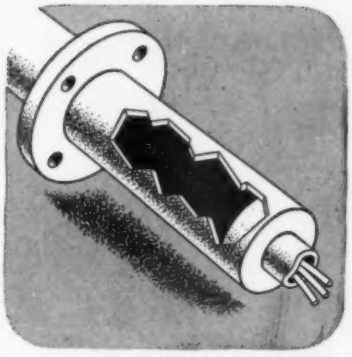
For these and 1001 other applications, new R/M Ray-BOND adhesives can be tailored to your needs

Adhesive bonding offers you many advantages. Because it eliminates rivets and other fasteners, your production costs are reduced and many assemblies otherwise difficult or impossible can be done with ease. With Ray-BOND adhesives, you can join dissimilar materials. Where unusually high or low temperatures constitute a problem, adhesive bonding frequently furnishes the ideal solution. It provides better heat conductivity, seals gaps and voids in metal products, and increases the life of friction members.

Ray-BOND Adhesives have proved themselves in a great variety of applications, and on products ranging from sewer pipes to snow trains, from ribbons to tool tips, from submarines to aircraft. They have been chosen because they resist temperatures as low as –80°F or as high as 700°F.

Raybestos-Manhattan offers you the benefit of more than 20 years of experience and pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings. Feel free to call on R/M engineers for their help.

Write now for your free copy of R/M Bulletin 700, containing engineering information on Ray-BOND adhesives, protective coatings and sealers.



Bonding vinyl jacket and steel gland in cable —protecting against moisture and corrosion.

Bonding brake linings for sub-zero operation in snow train.

Making weatherproof bond between sealer strip and car door.

R M

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT: Bridgeport, Conn.

Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Passaic, N.J.; No. Charleston, S.C.; Crawfordsville, Ind.; Neenah, Wis.; Paramount, Calif. Raybestos-Manhattan (Canada) Limited, Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Industrial Adhesives • Brake Linings • Brake Blocks • Clutch Facings • Industrial Rubber • Engineered Plastics • Sintered Metal Products Rubber Covered Equipment • Asbestos Textiles • Laundry Pads and Covers • Packings • Abrasive and Diamond Wheels • Bowling Balls

For more information, turn to Reader Service Card, circle No. 378

treated flakes must be uniformly distributed and laid flat in the mold.

Because of these limitations in processing and molding, Shibley and Rotschild recommend that a suitable method be developed for treating flake with resin; one which can be readily adapted to production techniques and which will lead to a suitable molding compound. Such a processing step should simplify and improve the molding step.

Air Hardening Steel for Tools and Dies

A new air hardening alloy tool and die steel is said to combine the safety and minimum size change of air hardening tool steels with the low cost, good machining characteristics and low temperature heat treatment of oil hardening tool steels.

Called Lo-Air, the material is available from Universal-Cyclops Steel Corp., Bridgeville, Pa. in the form of squares, rounds, flats and billets. The material is suitable for blanking, forming, coining and trimming of dies, punches, shear blades, spindles, mandrels and stripper plates.

According to the developer, the new alloy has better machinability than other widely used types of cold work tool and die steels. Tests show the alloy has a fatigue strength of 145,000 psi after 1 x 10^6 cycles and 120,000 psi after 100 x 10^6 cycles. AISI-O1 oil hardening die steel has a fatigue strength of 100,000 psi after 1 x 10^6 cycles and 95,000 psi after 100 x 10^6 cycles.

Heat treatment

Forging—Lo-Air tool steel should be forged at a temperature of approximately 2025 F; during forging, parts should not be allowed to cool below 1650 F.

Annealing—Best way to anneal

MECHANICAL PROPERTIES OF LO-AIR[a]

Yield Strength, psi	264,300
Tensile Strength, psi	292,500
Elongation, %	1
Reduction in Area, %	2.2
Static Bend, psi	660,000
Charpy Impact Str. (unnotched), ft-lb	120
Rockwell Hardness	C55

[a]Air cooled from 1550 F and double tempered 4 hr at 600F.

What's new IN MATERIALS

COMPOSITION OF LO-AIR, %

Carbon	0.70
Manganese	2.00
Silicon	0.30
Chromium	1.00
Molybdenum	1.35
Iron	94.65

the steel is in a controlled atmosphere furnace.

Stress relieving—Machining strains can be eliminated by stress relieving ½ hr at 1200-1250 F.

Hardening—Preheating is generally not necessary, but if used should be carried out in the range of 1200 to 1250 F. Parts should be placed in a furnace operating with a slightly oxidizing atmosphere at 1525-1600 F; allowed to come naturally to the temperature of the furnace; and aged for 20 min.

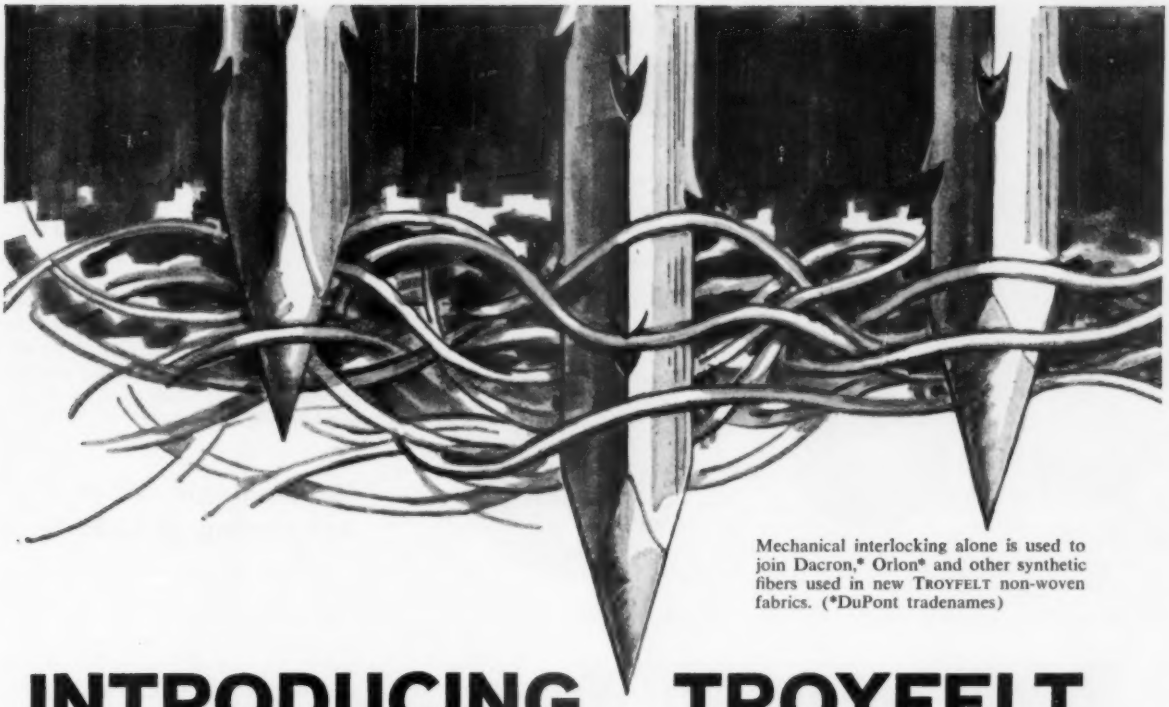
Tempering—A single temper is usually all that is required, with tempering carried out in the range of 300 to 1000 F.

Glass Pipe Insulation Usable up to 350 F

A rigid cellular glass pipe insulation has been developed for use over a temperature range of 35 to 350 F. According to the developer, the dimensionally stable pipe insulation costs about the same as other commercial pipe insulations.

The new material, called Foamglas Stay-Dry, is a product of Pittsburgh Corning Corp., 1 Gateway Center, Pittsburgh 22. Ease and speed of installation are two of the principal features of the new pipe covering, according to company engineers. The

***Installing** a new cellular glass insulation around a pipe.*



Mechanical interlocking alone is used to join Dacron,* Orlon* and other synthetic fibers used in new TROYFELT non-woven fabrics. (*DuPont tradenames)

INTRODUCING TROYFELT

a versatile new family of synthetic felts made without chemical binders

Where can you use these amazing new felts? Field-tested and proved for more than two years, these are typical reports:

A FILTER MAKER reports TROYFELT outperforming wool felts 7 to 1 in filtering highly abrasive Taconite ore.

AN ELECTRONICS firm finds TROYFELT a superior packing because it stays resilient at high and low temperatures.

A CUTLERY MAKER uses TROYFELT to polish stainless ware . . . finds its smooth surface gives higher luster, lasts longer.

. . . window makers use it as an impervious life-time seal . . . shoe makers because it lasts longer as a padding . . . gasket makers because it die cuts without ravelling . . . it's also used as wadding in cartridges . . . as a vibration isolator.

WHAT IS TROYFELT?

. . . basically, TROYFELT is a non-woven synthetic felt. It is available in Dacron, in Orlon, and in other synthetics. Unlike other non-wovens it has no chemical binders . . . the individual fibers are joined mechanically. Thus it is a softer material, a better insulator, a better filter, a better packing, padding and wick.

And yet TROYFELT *offers all the long-lived properties of the synthetics: a marked resistance to chemical attack, heat, abrasion and wear!*

Want *all* the facts? Just circle the number below on this magazine's handy reply card.

TROYFELT *. . . by the pioneers in non-woven synthetic felts*

INDUSTRIAL PRODUCTS DIVISION • TROY BLANKET MILLS

200 Madison Avenue • New York 16, New York

For more information, turn to Reader Service card, circle No. 410

insulation opens lengthwise and fits around the pipe; it can be installed before or after hanging the pipe.

The insulation is recommended for ice water lines, low pressure steam lines, hot water lines, chilled water lines and similar commercial piping installations. It is supplied in thicknesses of 1 and 1½ in.

Nonstrategic Alloys Are Strong at 1200 F

A series of iron-aluminum-manganese alloys combines lightweight and good cold workability with high temperature strength and good oxidation resistance. The materials, which contain no strategic alloying elements, are said to keep their strength at temperatures above 1200 F.

Expected to find use in aircraft, missiles and automobiles, the alloys are currently being evaluated by National Research Corp., 70 Memorial Dr., Cambridge 42, Mass. Tests to date show the materials have the following characteristics:

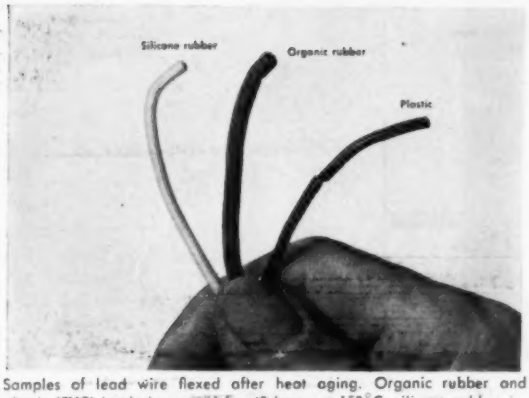
1. The materials are austenitic in structure and are about 15% lighter than carbon or 18-8 stainless steels, and 20 to 25% lighter than cobalt and nickel-base alloys.
2. Strain aging by heat treatment after cold working improves strength of the alloys after forming. Chromium-nickel austenitic stainless steels normally soften and lose strength if heated after cold working.
3. The alloys have good oxidation resistance at temperatures up to 1500 F.
4. Cold working properties of the iron-aluminum-manganese alloys approximate those of 18-8 stainless steel and permit cold forming by bending, rolling, swaging, drawing, stamping and similar operations.
5. Machinability is similar to that of type 304 stainless steel.

TFE-Treated Metal Is Wear Resistant

Flat and curved metal parts are now being vacuum impregnated with TFE resin to make them self-lubricating. The TFE impregnant is said to eliminate wear and to reduce

HOW TO SOLVE ELECTRICAL DESIGN PROBLEMS WITH

SILICONE IDEAS



Samples of lead wire flexed after heat aging. Organic rubber and plastic (PVC) insulations aged for 48 hours at 150°C, silicone rubber insulation aged 1,400 hours at 210°C.

New RTV Silicone Rubber Cures Without Heat, Does Not Shrink, Forms No Voids

Here is a brand new potting and encapsulating material that is easy to apply, cures at room temperatures and has outstanding heat resistance. Tough and elastic, G.E.'s new RTV room temperature vulcanizing compounds are stable up to 600°F, have excellent electrical properties. Viscosities vary from very pourable to spreadable. Can be applied by dipping, pressure gun, pouring or spreading.

RTV is quickly prepared for use, cures in any time you select up to 48 hours. 100% silicone solids (solvent free), it cures without shrinking or forming voids. Flows easily into complicated shapes. Write for technical data. Samples available for evaluation—just give us a brief description of your application.

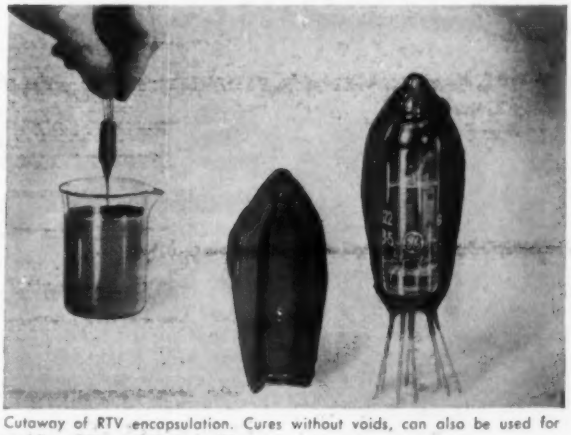
Comparative Properties	SR-155	Silicone X	Silicone Y
Penetration & wetting	Excellent	Good	Good
Low temperature craze resistance	Excellent	Fair	Excellent
High temperature stability	Excellent	Excellent	Excellent
Overcoating	Excellent	Excellent	Fair
Blister free	Excellent	Excellent	Excellent

Chart compares essential properties of General Electric SR-155 varnish with other silicone varnishes.

Silicone Rubber Insulated Lead Wire Takes The Weak Link Out Of Class B Equipment

The weak point in Class B motors, generators and transformers is often the lead wire. At little or no extra cost, this potential failure point can be eliminated by silicone rubber insulated lead wire, standard for high temperature operation. Silicone rubber upgrades the performance and sales features of Class B equipment, provides a safety margin for overloads.

Cost economies are possible, too. You can standardize on one type of lead wire for both Class B and Class H equipment. Equipment can be baked with lead wires already attached, saving an extra operation. Check into *all* the advantages of silicone rubber for Class B use: high-temperature resistance, moisture resistance, low temperature flexibility, stripping ease and others.



Cutaway of RTV encapsulation. Cures without voids, can also be used for molding, filling, sealing, caulking.

New Silicone Varnish Is Easier To Apply, Protects Over Wider Temperature Range

SR-155, General Electric's new silicone varnish, is a Class H insulating material which offers superior performance from −65°C to over 200°C. It will not craze or crack at sub-zero temperatures.

Because it easily handles excessive emergency loads, SR-155 increases the reliability of electrical equipment. Since it is suitable over a wide temperature range this one varnish can take the place of two or more, so manufacturing procedures and inventory can be simplified. Its smooth, glossy finish improves appearance. SR-155 penetrates deeper than other resins, "wets out" well and will not bubble. Write for application information.

Send for more information.

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

Section D11B4, Silicone Products Dept., General Electric Co., Waterford, N. Y.

Please send me further data on: ☐ SILICONE RTV RUBBER ☐ SILICONE RUBBER WIRE INSULATION ☐ SILICONE VARNISH

Name_____ **Title**_____

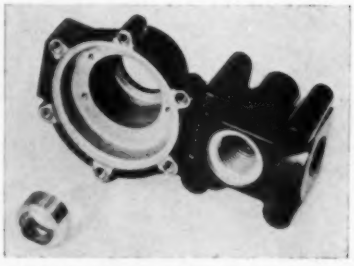
Company_____

Address_____

City_____ **Zone**_____ **State**_____

For more information, turn to Reader Service card, circle No. 546

What's new IN MATERIALS



***TFE-impregnated part** has good wear resistance.*

costly replacement of moving metal parts. The impregnation process was developed by Western Sealant Co., Div. of Consolidated American Services, Inc., 9999 W. Jefferson Blvd., Culver City, Calif.

According to the developer, TFE is integrally bonded into the metal with the process. The TFE resin does not bleed out of parts under friction, heat and pressure.

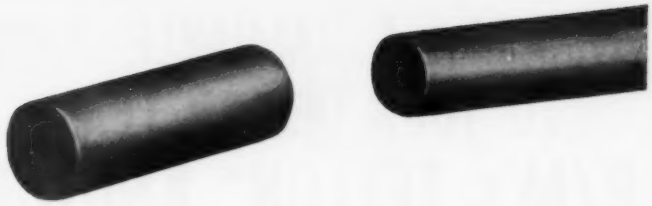
Large Extruded Pipe Made of Polyethylene

A high density polyethylene pipe compound previously discussed in this magazine (M/DE, Sept '57, p 168) is now being extruded into large diameter pipe by a new extrusion technique, details of which have not been revealed by the company. The large diameter pipe can be made in any length and can be securely joined by flanging. It is commercially available from Carlon Products Corp., Aurora, Ohio.

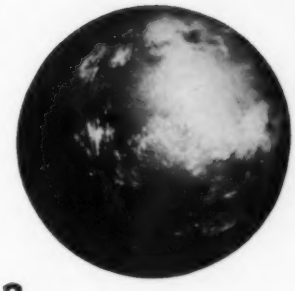
The high density compound, developed by Allied Chemical Corp., 61 Broadway, New York 6 and called A-C polyethylene pipe compound, cannot be extruded by ordinary methods because of its high melt viscosity.

Test data from Allied Chemical's research laboratory show pipe made

DON'T MISS AN ISSUE — Changing your address? If so, please let us know two months in advance. With such notice, which we need for efficient operation, we will do our best to see that you don't miss an issue. Be sure to include your new postal zone number.



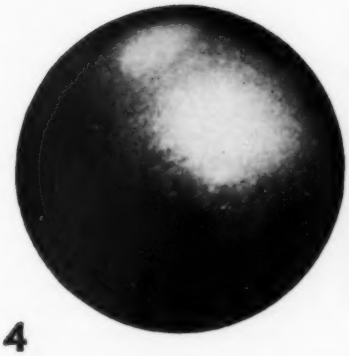
Making case-hardened balls from cold-heading wire



Changing a length of straight steel wire into a precision-finished bearing ball might seem like fitting a square peg into a round hole. Yet that's the way case-hardened balls are made, and with the proper type of Bethlehem ball-quality wire the results are gratifying indeed.

The trick really lies in producing the right wire for this severe heading operation, along with the dry grinding, hardening, tumbling, and finishing steps that follow. Bethlehem cold-heading quality wire passes these tests with flying colors.

In fact, Bethlehem wire has performed consistently for a wide variety of cold-headed parts, from rivets and screws to complicated custom-headed items. You can depend on Bethlehem wire to be uniform in quality, temper, and finish. Most important, you can count on Bethlehem to furnish the *right* steel wire for your job. Let us know if we can help you with any wire problem you may have. Just call our nearest district sales office.



Steps in making a case-hardened ball: 1. Wire cut to size. 2. Cold-head. 3. Grind. 4. Harden and Tumble. 5. Finish.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 552

What's new IN MATERIALS

Allied Chemical Corp.

***Plastics pipe** extruded from high density polyethylene is said to compete in price with steel, cast iron ceramic and fiber pipes.*

of the compound has a useful life expectancy of 50 years. In addition, investigation shows no cracking, slitting or pinholing in the pipe. In a typical test the pipe was cycled 90,000 times to three times normal pressure for 1 sec out of every 10 with no deterioration.

Pure Chromium Made by Electrodeposition

Recent research by F. E. Block, P. C. Good and G. Asai of the Bureau of Mines, Albany, Ore., indicates that high purity chromium metal can be prepared conveniently by electrodeposition. Electrolytic chromium has tensile properties comparable to those of chromium made by refining commercial grade material.

The work of Block, Good and Asai, reported in the Jan '59 issue of the *Journal of the Electrochemical Society*, consisted of using a high temperature chromic acid bath operated at high current densities to yield thick deposits of low-oxygen chromium.

Series of Silicone Oils for Electrical Uses

A series of electrical-grade silicone fluids has been developed. Designated SF-97, the fluids are supplied in viscosities of 50, 100 and 1000 centistokes. They are now commercially available from General

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

HOW TO TAKE A SNAPSHOT OF A SATELLITE IN FLIGHT

If snapshooting satellites is on your agenda, contact either Boller & Chivens/-Joseph Nunn, South Pasadena, California, or the Perkin-Elmer Corporation, Norwalk, Connecticut.

In collaboration, these two firms make just what space photographers need. It's called the IGY Satellite Tracking Camera. And, of necessity, it's somewhat larger than the cameras most of you are accustomed to using. Like this.

Twelve of these cameras are now in use around the world. Each is designed to, first, take a picture when fixed on and following the *satellite*. This renders the subjects as a point against a background of streaks from the brightest stars. Then a second exposure is taken with the camera fixed on and moving with the *stars*. This provides the reference for determining the satellite's location.

And us? We provide the mirror blanks for Perkin-Elmer, who in turn handle the complete optical system. (The West Coast firm provides mechanical components and does the assembling.) The blanks we furnish are 31¾″ in diameter and 7″ thick. They are made from glass No. 7160, the very same glass used in casting the now-famous, 20-ton, 200″ disc for the Mt. Palomar Observatory.

The big advantage in using this particular glass is its very low linear coefficient of expansion—23 x 10^{-7} per ° C. Low expansion means a minimum of distortion, a much-appreciated contribution in the complex optics called for in taking pictures of satellites.

These king-sized mirrors lead us quite naturally to remind you that *Corning can do almost anything with glass*. Find out for yourself. Get a copy of "This Is Glass." Use the coupon for quick service.

NEW GIANT GLASS FLASK FOR THE IN-BETWEEN TASK

What intrigues the man in the picture is the *size* of the crystal clear vessel he is examining.

His interest is justified because as far as we know this is the *biggest* all-glass reaction flask on the market. It's new; it measures 18 inches in OD and stands 26 inches high. Capacity is 20 gallons.

We provide this size—along with 5 and 10-gallon versions—for people (maybe you) who need to fill the gap between lab and pilot plant.

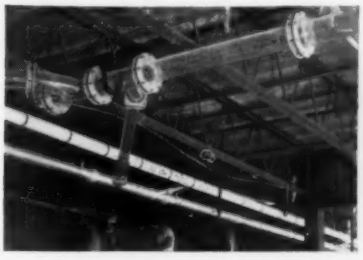
You also can get all the trimmings. Like the five-opening all-glass cover that's visible behind the flask. Such covers can be had with pipe flanges, ₹, or socket joints. Accessories include inlet tubes, condensers, blind caps, clamps and thermometer wells. Need one? Just write for details.

This outsized glassware is all made from PYREX brand glass No. 7740—a glass that performs admirably because of the virtues detailed elsewhere on this page.

Which brings us to this diminutive and relatively intricate container known as a Warburg flask. It's quite commonplace to biochemists who use it for measurement of cell respiration and tissue metabolism. It's also a stock item with us.

We call the big ones and the little ones *both* to your attention because it points up the fact that size or shape is a consideration—*not* a limitation—to the skilled glassworkers at Corning.

Investigate by tossing us any one of your tough problems. We'll look for a glass answer and let you know soon what we can do.



PLUMBING FOR POSTERITY

An increasingly popular fixture in labs, hospitals, schools, chem plants, and photoengraving shops is the glass drainline.

With good reason. Glass drainlines are fashioned from PYREX brand glass No. 7740.

This is the glass that ends your worries about corrosion. For example, if you were disposing of waste hot hydrochloric acid, your PYREX pipe would still be around at the end of 200 years.

And glass is smooth; very little chance for block-up in the pipe. If such does occur, however, you can spot the exact point and take corrective action, without having to take down the whole system.

In fact, almost anything made from PYREX brand glass No. 7740 will be around for quite a while because this glass is able to cope with thermal shock and physical knocks, too.

Available in many forms—tubing, rod, pipe, plate, and all kinds of shapes.

Fill in the gaps in your files with these basic references: PE-30, all about glass drainlines; IZ-1, design considerations in glass. Any or all, free. Use the coupon.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 50 Crystal Street, Corning, N.Y.

Please send me; ☐ "This Is Glass"; ☐ Drainline Manual, PE-30; ☐ Design Manual IZ-1; ☐ Info on Reaction Flasks

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

For more information, turn to Reader Service Card, circle No. 389

PROPERTIES OF SF-97 FLUIDS

PHYSICAL PROPERTIES	
Specific Gravity	0.964
Flash Point, F	559
Pour Point, F	−67
Viscosity-Temp Coef	0.586
ELECTRICAL PROPERTIES	
Dielectric Strength, v/mil	32.5
Dielectric Constant (10^5 cps)	2.75
Dissipation Factor (10^5 cps)	0.001
Volume Resistivity, ohm-cm	1×10^{14}

Electric Co., Silicone Products Dept., Waterford, N. Y.

According to GE, the electrical-grade fluids are designed for use in capacitors, pulse transformers, specialty transformers, airborne and land-based radar equipment, and television circuit components.

Polyester Paint Cures to Tile-Like Finish

A polyester coating, described as a thermosetting, self-baking material, cures to a tile-like finish on concrete, plaster, wallboard, wood and metal. Called Glid-Tile, the coating is available from Glidden Co., 11004 Madison Ave., Cleveland 2, Ohio.

The cured coating withstands acids, solvents, alkalis and hot water, and is impact and abrasion resistant. According to the producer, the coating can be cleaned with strong detergents without damage.

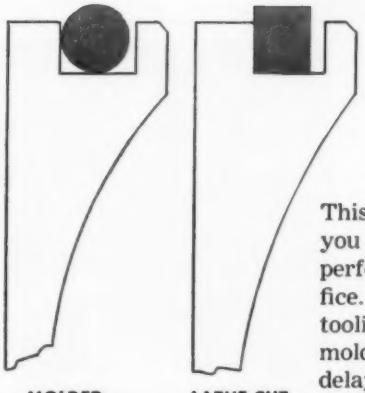
Epoxy Adhesive Bonds Well to Glass, Metals

A one-part epoxy adhesive develops high bond strengths to most ferrous and nonferrous metals, glass, plastics and ceramics. The adhesive, when bonded to aluminum, has a shear strength exceeding 3000 psi. Bonds to glass are said to be so strong as to be beyond measurement. The material is said to be useful at temperatures from −70 to 170 F.

The adhesive, a product of Isochem Resins Corp., 221 Oak St., Providence 9, R. I., is called Isobond 331. It has a shelf life of six months and cures rapidly at moderate tem-

Why ACADIA LATHE-CUT SYNTHETIC RUBBER SEALS

can save you money in *STATIC* or *MOVING* seal applications



MOLDED O-RING SEAL

LATHE-CUT SEAL

This seal will save you money with no performance sacrifice. Minimum tooling cost, no molds, no costly delays. Can be made up to 25" I.D.

Acadia Synthetic Rubber Parts are of the highest quality components, processed for oil resistance, good aging properties, resistance to heat. They can be furnished in any dimension or special compound you desire to precision tolerances. They are another example of Acadia's ability to SAVE YOU MORE..SERVE YOU BETTER.

There's an Acadia Sales engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA *Synthetic* **PRODUCTS**

DIVISION OF WESTERN FELT WORKS
Dept. D, 4021-4139 West Ogden Avenue, Chicago 23
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

For more information, turn to Reader Service card, circle No. 497

What's new IN MATERIALS

PROPERTIES OF ISOBOND 331

PHYSICAL PROPERTIES	
Specific Gravity	1.18
Water Absorption (24 hr), %	0.02
MECHANICAL PROPERTIES	
Lap Shear Strength, psi	
Aluminum-to-Aluminum	3200
Brass-to-Brass	1850
Glass-to-Glass	Glass fails
Barcol Hardness	48
ELECTRICAL PROPERTIES	
Volume Resistivity, ohm-cm	2×10^{16}
Dielectric Strength, v/mil	400
Dielectric Constant (1000 cps)	4.4
Power Factor (1000 cps)	0.009

peratures. In addition, it has good resistance to most acids, alkalis and solvents.

(more What's New on p 182)

Continuous preforming device—Workman demonstrates a new device for preforming glass fiber roving on a continuous basis. The new unit is said to eliminate the 5 to 10% loss in glass usually incurred in the conventional chopped strand preforming process. According to the developer, Johns-Manville Fiber Glass Inc., Toledo, Ohio, the device is best suited for producing symmetrical articles such as waste baskets and tote boxes.

In the device, glass roving is first metered to a hand-operated air gun which projects the glass roving onto a preshaped, preforming screen. Air drawn through the screen attracts the resin binder and the uniformly swirling glass roving coming from the gun. Up to 6 lb of glass per min can be deposited on the screen by varying the speed of the metering device and the number of strands fed into the gun.

"Dad believes in good guns and good gun manners"

"He just bought me a new gas-powered Hahn BB rifle. It's real sharp and shoots straight, but he won't let me use it alone until I've learned good gun manners."

Hahn BB guns, styled after famous lever-action Western frontier rifles, have the look and feel of Dad's guns—and they shoot straight. This is due to the accuracy of the barrels. They are made from commercial grade Superior carbon steel tubing —known for the consistent uniformity of its ID finish, free machining characteristics and economy.

Examples of other unusual applications of this Superior tubing

- Carbon steel rectangular tubing for collimating tubes in a research reactor (.900 in. x .400 in. ID x .025 in. wall in 10-ft. cuts)
- Specially conditioned ID tubing in long lengths used as high pressure diesel lines on earthmoving equipment (¼ in. OD x .088 in. ID)
- Cadmium plated compression sleeves for connecting the steel core of ACSR high tension cable (.404 in. OD x .179 in. ID in 5-in. cuts)
- 2½ million ft. of carbon steel tubing in random lengths for the gear pinion in the timing fuse of artillery shells (.204 in. OD x .067 in. ID)

Filling tubing orders that range from a few feet to millions, in a wide variety of materials, shapes and sizes, calls for the resources Superior has to offer. Why not investigate the advantages of using us as a source of tubing. Bulletin 41, a guide to the selection and application of Superior tubing, is yours for the asking. Write Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

For more information, turn to Reader Service card, circle No. 504

What's new IN MATERIALS

Titanium Tubing Can Be Bent to 90-Deg Angles

A modified cold bending technique has been developed whereby titanium tubing can be bent to 90-deg angles without damage.

The tubing is drawn around a rotating bending form, which is held in position under pressure and supported by means of special moving clamps, dies and mandrels. Bending cycles are carefully controlled. The combination of special equipment and techniques is said to minimize wrinkling of the tubing when making extremely sharp bends.

The tubing is bent on angles up to 90 deg on a radius equal to the outside diameter of the tubing for many configurations. For example, tubing with an o.d. of 0.750 in. and a wall thickness of 0.035 in. has been bent to 90-deg angles on a 0.750-in. radius.

The bending technique was developed by Kreisler Industrial Corp.,

Superior Tube Co.

Bending machine, *equipped with moving clamps, dies and mandrel is used to bend . . .*

. . . titanium tubing *into a variety of shapes.*

Failure of any part of a missile—be it the mighty Atlas, Jupiter or Thor—can mean failure of the mission. That's why the complex connections in the ducting systems of these and other missiles are silver brazed. These connections must stand up under 6,000 psi; they are tested to 12,000 psi.

In lines made to specifications by Flexonics Corporation, Maywood, Illinois, silver brazing joins a corrugated flexible pressure carrier, a braid sleeve and a coupling nipple—all of stainless steel; it permits joining all of these elements of the assembly without danger of annealing the pressure-carrying flex or the restraining braid as welding might do.

Assemblies designed for 6,000 psi operating pressure are required to withstand a 12,000 psi test and take four times their normal operating pressure before failure. They may also be required to pass a flame test in order to meet specifications.

The silver-brazed connections are used on hydraulic and pneumatic systems, fuel drain lines and vent tubes. Some of these applications involve rigorous service with extreme pressure shocks accompanied by sudden elevations of temperature, which may go from −60° to 400-600° F in a matter of seconds.

A more "high level" endorsement of Handy & Harman silver alloy brazing is not available. On the ground or in the air, the qualities of this remarkable metal joining method apply; strength, ease of production, cost, gas and liquid joint tightness to name a few. The entire brazing story is yours merely for the asking. Inquiries and metals-joining "problem exposure" may be addressed to Handy & Harman, 82 Fulton Street, New York 38, N. Y. We welcome the opportunity to work with you.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

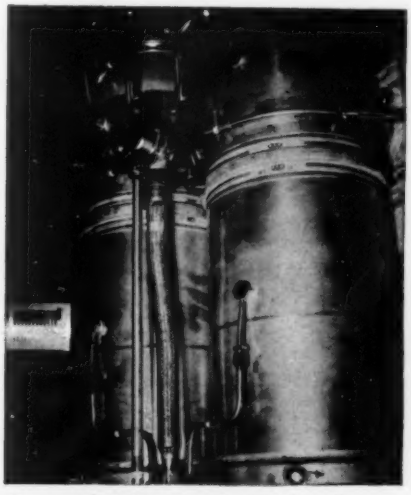
DISTRIBUTORS IN PRINCIPAL CITIES

No Margin Here for joint failure!

Assemblies in ATLAS Missile

HANDY & HARMAN Silver Brazed

Intercontinental Atlas missile being made ready for launching.



Close-ups of missile section, showing silver alloy brazed ducting assembly.

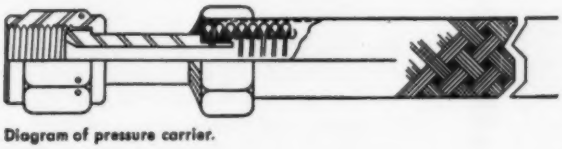


Diagram of pressure carrier.

FOR A GOOD START: BULLETIN 20.

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

For more information, turn to Reader Service Card, circle No. 462

What's new IN MATERIALS

Paterson, N. J., using a soft annealed, commercially pure titanium tubing supplied by Superior Tube Co.

Reinforced Plastic Insulates at 4000 F

An organic fiber-reinforced thermosetting plastic, composition of which has not been revealed, shows promise as an insulating material in missiles subject to temperature of 4000 F and up. The developer says temperature range of the material extends well above that in which phenolic-asbestos and phenolic-glass insulations are currently operating.

The insulating material, called Orbiton, was developed by Haveg Industries, Inc., Missile Div., 900 Greenbank Rd., Wilmington 8, Del. It is expected to find use as an insulation in such missile parts as exit cones, blast tubes, tail pipes, guide vanes, motors, jet vanes and launching pads.

The company says Orbiton is fabricated by laminating, compression molding and filament winding.

Other News . . .

Metals

▸ Aluminum pipe, said to have increased strength and thickness at pipe ends, has been introduced by Reynolds Metals Co., Richmond 18, Va. Pipe ends are identical to those of standard pipe and are adaptable to grooving and threading for mechanical fittings.

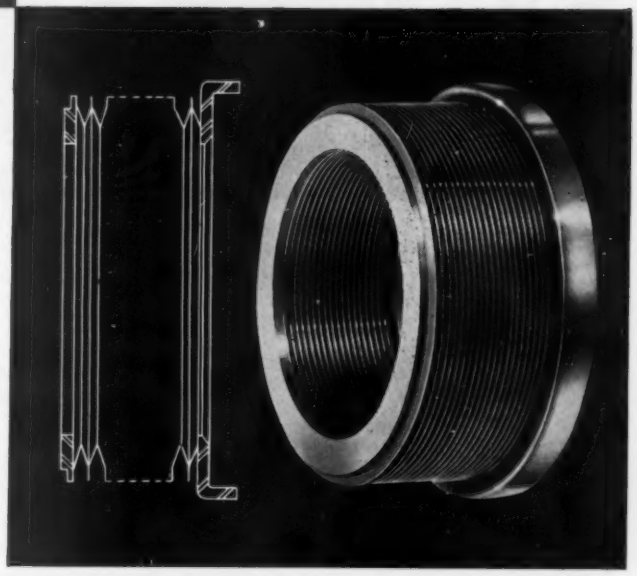
▸ Bars of an aluminum-tin alloy can be machined into bearings of any size. The bars are marketed by Bunting Brass & Bronze Co., 715 Spencer St., Toledo 1, Ohio.

▸ What is described as the world's smallest steel tubing, 0.0014 in. o.d. x 0.0005 in. i.d. x 0.00045 in. wall thickness, is now available from Superior Tube Co., Norristown, Pa. The tubing is also supplied in nickel, beryllium copper and titanium.

▸ Darwin & Milner, 2345 St. Clair Ave., Cleveland 14, Ohio is now supplying bars of an air hardening cobalt-base tool steel (designated PRK-33) in sizes ranging from ¼ to 6 in. Formerly, the material was only

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1227 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

For more information, turn to Reader Service card, circle No. 419

What's new IN MATERIALS

available in rounds to 10 in. and in flats to 4 x 10 in.

▸ Cold finished alloy steel bars are available from Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30 with a lead addition for good machinability. The leaded steel bars are called Jalcase 100-L.

Nonmetallics

▸ A radiation shielding material made of vinyl and lead is said to withstand radiation from 100,000 to 1,000,000 r with no change in physical properties. The material, called Leadx, is available from Bar-Ray Products, Inc., 209 25th St., Brooklyn 32, N. Y.

▸ Emerson & Cuming, Inc., 869 Washington St., Canton, Mass. has introduced two new ceramic foams for use in electrical and electronic devices. The producer says both foams can be used at temperatures of 1000 F and above. One, called Eccofoam LM-43A, is supplied at dielectric constants from 1.3 to 1.6; the other, Eccofoam WC-8, is supplied at dielectric constants from 1.7 to 5.0.

▸ A mat-faced fiberglass lining material has been introduced by Owens-Corning Fiberglass Corp., Toledo 1, Ohio for use on cold and hot air conditioning metal ducts. The producer says its flexible duct liner has good resistance to moving air. The liner is manufactured in ½ and 1-in. thicknesses, and is available in widths of 24, 36 and 48 in.

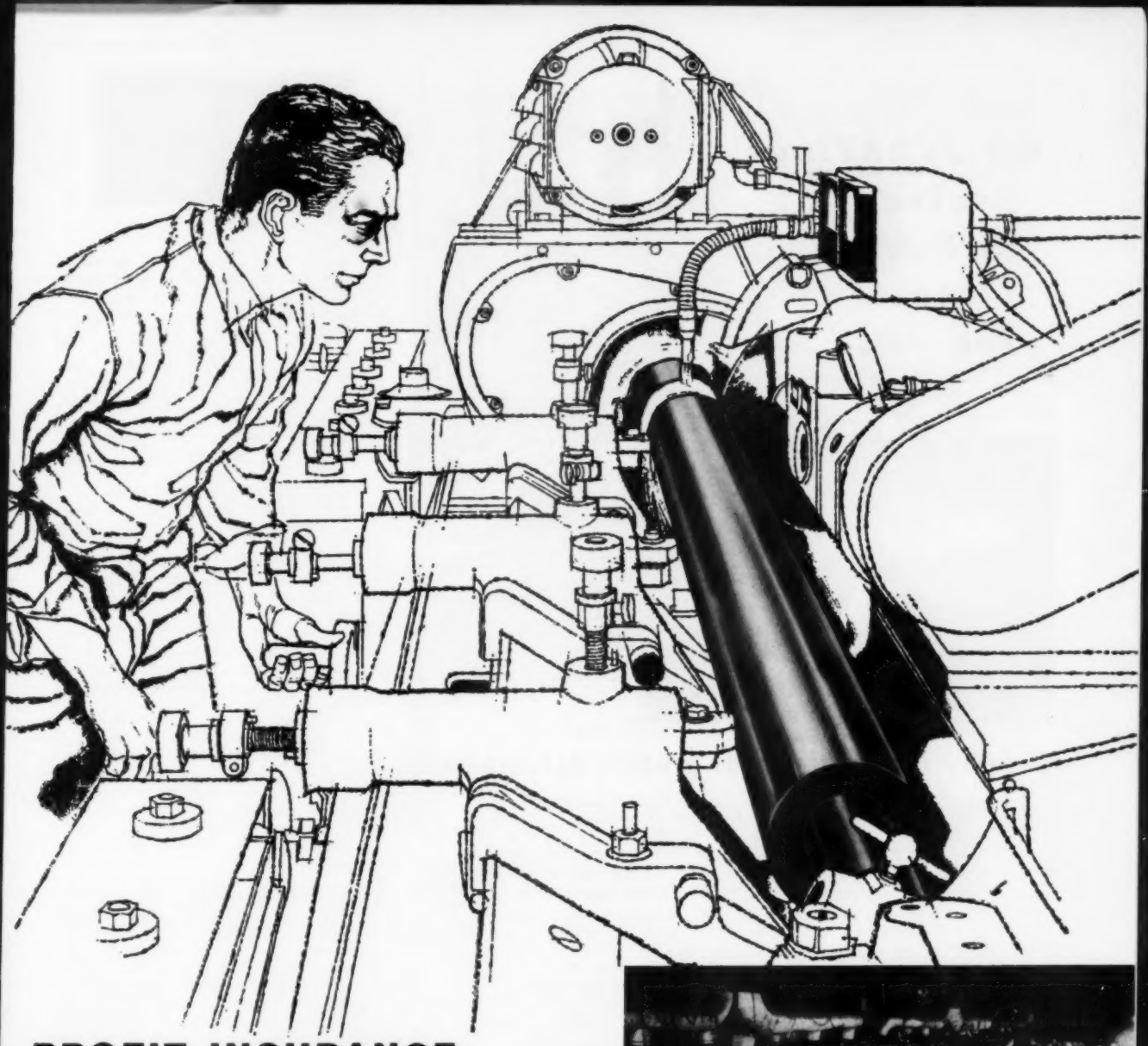
▸ A vinyl upholstery material called Roma is said to have the look and feel of brocade, yet is washable and durable. Developed by United States Rubber Co., 1230 Avenue of the Americas, New York 20, the upholstery material has an elastic backing for easy fitting around contours.

▸ Surfaces of formed stainless steel and other metal products can be protected from scratches and the effects of weathering by using a new, paper-backed tape called Protecto-Mask. The self-adhering tape is rolled on sheet metal before forming, than easily stripped away when the product is put to use. The tape is a product of Mystik Adhesive Products Inc., 2635 N. Kildare Ave., Chicago 39.

Finishes

▸ A corrosion, oxidation and abrasion resistant nickel coating has been developed by Todco, P. O. Box 229, Whittier, Calif. for use on ferrous

For more information, circle No. 502 ➤



PROFIT INSURANCE with J&L Stainless Steel Bars

Your machining costs on stainless steel bars are part of your investment for profit. Add your costs for tooling, handling and polishing, and you multiply your investment, often many times over.

Scrapping a single bar wipes out that investment—and with it most of your profit on a large volume of finished goods.

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J&L leads the industry in melt shop standards for stainless steel —the point where quality starts, **and your profit insurance begins.**

Careful attention to every production detail is the key to J&L quality

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What's new IN MATERIALS

metals and copper. The producer says the coating, designated Pyro-Plates, is fused into the surface of the base metal after baking at 1650 F.

▸ A new power brush, called TY, has been introduced by Osborn Mfg. Co., 5402 Hamilton Ave., Cleveland 14, Ohio for such operations as: 1) finishing metal; 2) roughening leather and rubber to achieve good bonding characteristics; 3) stripping insulation from electrical conductors; and 4) removing excess varnish from armatures.

▸ Development of a phosphate material for use as an anti-friction "break-in" coating and as a foundation for oil and paint has been announced by Turco Products, Inc., 6135 S. Central Ave., Los Angeles 1, Calif. The material, called Turcoat 3557, can be applied to iron, steel and cadmium.

▸ Bart Mfg. Corp., Belleville, N. J. has introduced a zinc-rich paint containing from 92 to 95% metallic zinc in the dry film. The paint, called Galvafroid, is said to give corrosion protection to metal products comparable to that afforded by hot dip galvanizing.

Joining materials

▸ A new heat-sealing adhesive has been introduced by Adhesive Products Corp., 1660 Boone Ave., New York 60 for bonding fabrics, leather, paper and plastics to themselves and to other materials. A coated material may be bonded days, months or years after application of the adhesive.

▸ A liquid plastic cement, called Nicrobraz, has been developed for applying powdered brazing alloys to stainless steel assemblies. The cement is available in six different viscosities from Wall Colmonoy Corp., Stainless Processing Div., 19345 John R St., Detroit 3.

Testing equipment

▸ A wall-mounted tensile tester is available from Steel City Testing Machines, Inc., 8817 Lyndon Ave., Detroit 38. The machine can be adjusted to test specimens from 5 to 13 in. long. Models are available with capacities up to 40,000 psi.

▸ Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y. has introduced a modified impact tester that can be used to conduct Charpy and Izod impact tests and tension impact tests on plastics and ceramics.

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Bronze or Iron
Bearings... Bushings... Parts
Offer Many Important Savings

Pre-Lubrication—The porous structure of Johnson Ledaloyl acts as a reservoir for the lubricant, providing sufficient oil during operation . . . storing it when at rest. This feature often eliminates costly lubricating devices and systems, guards against neglect and assures longer operating life of the unit.

Formed to size—The manufacturing process of Johnson Ledaloyl is essentially a forming and sintering operation. This eliminates machining, prevents scrap, yet provides accuracy at a low unit cost. Uniformity of each bearing, or part, cuts assembly time to a minimum. These are but two of the many money-saving features of Johnson Ledaloyl bearings, bushings, and structural parts. Let us show you how to design your product to take full advantage of this economy yet gain greater performance and longer service life. No obligation of course. Write for literature today.

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Johnson Bronze

769 South Mill Street • New Castle, Pa.

Subsidiary: Apex Bronze Foundry Co., Oakland, California

JOHNSON Bearings

For more information, turn to Reader Service Card, circle No. 390

Errata

***Materials Selector* Issue**
Mid-October, 1958—Vol. 48, No. 5

Please make the following corrections and additions in your current *Selector* issue—or simply cut out and attach this column inside the back cover of the issue.

DATA SECTION

P 7—change page numbers 12, 13 and 14 to 11, 12 and 13, respectively; add Tensile Strength . . . 14; change page numbers 17, 19, 21, 22 and 23 to 16, 18, 20, 21 and 22, respectively

P 92, col 2, line 10—change from 479 to 39.9; col 4, line 10—change from 101 to 8.41; col 5 and 6, line 12—change from "yes" to "no"

P 176, col 6, line 9—change from 0 to −50; line 10—change from 210 to 300; line 15, change from A40-A75 to A40-90; line 19—change from "Fair" to "Good to excellent"; line 21—change from "Very good" to "Excellent"; line 25—change from "Good" to "Very good"

P 177, col 3, line 4—change from 67 to 0.11-0.12

P 228, col 1, line 21—change from "ohms/cu cm" to "ohm-cm"; col 2, line 4—change from 5.7 x 10^{-6} to 3.16 x 10^{-8}; col 3, line 4—change from 0.7-2.0 x 10^{-8c} to 0.39-1.1 x 10^{-6c}; line 19—change from 10^{10} to 1.26 x 10^{5}; line 21—change from 4 x 10^{8} to 6.31 x 10^{8}

P 229, col 1, line 22—change from "ohms/cu cm" to "ohm-cm"

P 237, col 1, line 8—change from "Ten Str, psi" to "Ten Str, 1000 psi"; col 5, line 7—change from "Crude ⅜-¾" to "Crude ⅜-2"; line 21—change from "Fair, embrittles" to "Exc"

DIRECTORY SECTION

P 419, col 1
Clad Metals—add: Jessop Steel Co. (g)

P 422, col 1
Diffusion Coatings—add: Chromizing Co.

P 423, col 4
Expanded Metals—add: Wheeling Corrugating Co.

P 426, col 2
Forgings—add: Jessop Steel Co. (g)

P 450, col 2
Steel, Heat and Corrosion Resistant—add: Jessop Steel Co. (o,q,z,cc,dd,ee)

P 452, col 2
Steel, Tool and Die—add: Jessop Steel Co. (o,q,z,cc,dd)

P 453, col 4
Tubing, Pipe—add: Jessop Steel Co. (g)

P 461, col 1, line 83—change to: W. 117th St. (delete Berea Rd.)

P 463, col 1, line 63—change from 58-99 54th St., Maspeth 78, N. Y. to: 32-21 Downing St., Flushing, N. Y.

P 463, col 4, line 44—add: Chromizing Co., 1721 E. 47th St., Los Angeles 58, Calif.

P 469, col 1, line 84—add: Jessop Steel Co., Washington, Pa.

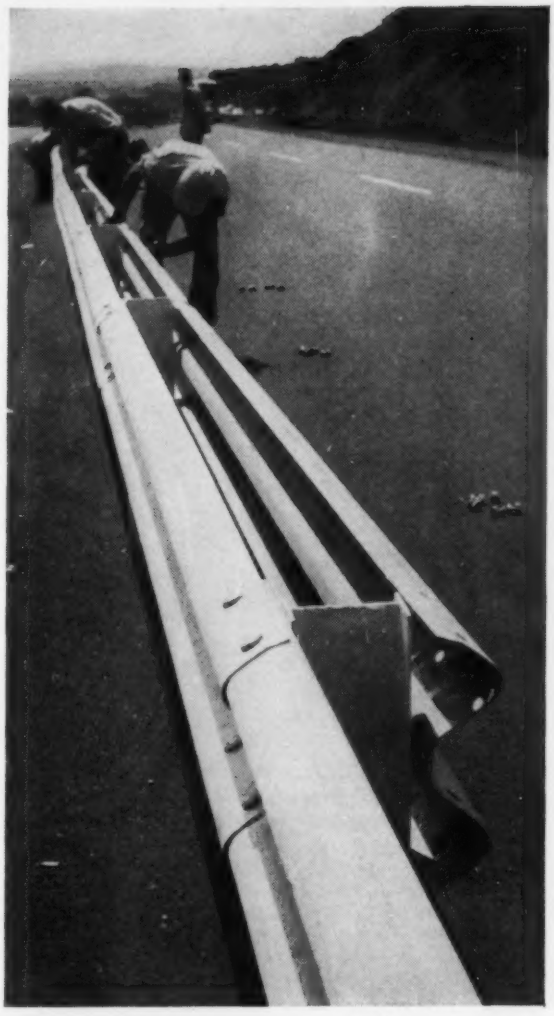
P 475, col 4, line 25—change to: Sorbo-Mat Process Engineers (Ad p 355)

P 478, col 2, line 22—add: Wheeling Corrugating Co., Wheeling, W. Va.

USE THE 'SELECTOR'—You will find properties of most engineering materials, plus names and addresses of suppliers, in M/DE's *Materials Selector* reference issue, published last October.

Hot-Dip Galvanizing Replaces Painting

...and Proves A Life Preserver For Highway Life Guards



It is estimated that road building to the extent of six billion dollars will make 1959 the biggest highway construction year since Congress, in 1956, authorized the 41,000 mile interstate highway system.

Last year, as a part of this continuing program, 11 miles of hot-dipped galvanized guard rail were installed on the Pennsylvania Turnpike near Somerset, Pa. The rail was galvanized after fabrication and delivered to the site as needed. Under normal conditions, construction crews installed an average of 3000 feet per day. For complete protection against atmospheric corrosion, galvanized bolts were used to fasten the rails in place. This type of double faced guard rail has become increasingly popular especially on older highways where narrow medial strips are a hazard.

Noteworthy is the proven fact that the ultimate cost of hot-dip galvanizing is lower than painting because it eliminates the recurrent expense of *re-painting*.

Here is an example

The hot-dip galvanized bridge railing shown here was installed on the Merritt Parkway near Milford, Conn. in 1938. *In the ensuing 20 years it has retained its appearance and strength without painting.* This is just one of the many installations where galvanized steel is saving the nation's Highway Departments millions of maintenance dollars every year. Thanks to the protective zinc coating, galvanized highway structurals are immune to atmospheric corrosion and have the added advantages which the inherent strength of steel provides.

ASTM SPECIFICATIONS

Steel products to be galvanized after fabrication, and designed for installation on inter-state highways, are covered by ASTM Spec. A123 and apply to:

- Bridge Structurals
- Decking and Railing
- Grating
- Fence Posts
- Sign and Reflector Supports
- Expansion Plates
- Rocker Plates
- Guard Rails
- Lighting Standards

NOTE: ASTM Spec. A123 is, in most cases, identical to the corresponding spec. of the American Assoc. of State Highway Officials, e.g., ASTM A123 is the same as AASHO Spec. M111-55.

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For more information, turn to Reader Service card, circle No. 537

New ideas . . . new designs with LUCITE®

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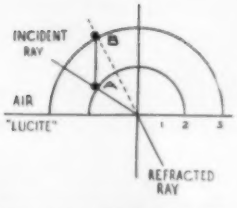
AN ENTIRE LENS SYSTEM molded in two pieces: Twenty-four lenses—precise, brilliant, economical—form the optical backbone of this digital read-out unit for computers and electronic instruments. Lenses of LUCITE have high dimensional stability and impact strength . . . are light in weight. (Lenses by Craftsmen's Guild, Hollywood, Calif.; display unit (patent applied for) by Industrial Electronic Engineers, Inc., North Hollywood, California.)



EASY WAY TO FIND THE ANGLES. The index of refraction of LUCITE is 1.49. Since this is practically a 1.50/1 or 3/2 ratio, it is easy to construct the path of a light ray through LUCITE. Draw two semicircles as shown, centered at the point of intersection of the incident ray. Draw a perpendicular from point A on the inner circle to point B on the outer circle. The continuation of the line drawn from B through the origin gives the path of the refracted ray.

EVEN if LUCITE did not possess its brilliant transparency, you would want to use it in your designs for its other valuable properties. LUCITE is a strong material—stronger in some respects than plastic materials that are known primarily for high strength. LUCITE is outstanding for resistance to sunlight, weathering and many classes of chemicals. The resin can be economically molded with a high degree of accuracy. With recent developments in LUCITE, the design possibilities are rapidly widening.

WRITE FOR VALUABLE NEW BOOKLET. Title: "A New Look at the Product Design Qualifications of a Popular Plastic, LUCITE." See how LUCITE makes possible new uses, greater sales potential. The address: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 20-04, Du Pont Bldg., Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

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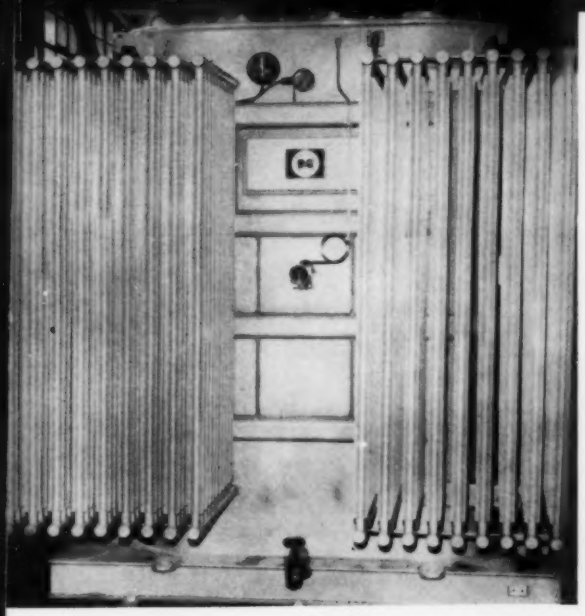


MATERIALS AT WORK

cont'd from p 12

First All-Aluminum Power Transformer

Shown above is what is said to be the first all-aluminum power transformer made in this country.

According to Moloney Electric Co., aluminum is used for all metal parts of the giant transformer except the core and the straps used to hold the core together. Aluminum parts are: tank and structural members, coil windings and extruded finned tubes. In all, the 12-ft high transformer uses over six tons of aluminum. According to Aluminum Co. of America, the unit is 40% lighter than it would be if made of conventional materials.

The transformer has a theoretical thermal capacity of 6000 kva—far in excess of the standard 3750 kva specifications to which it was built—as a result of aluminum's high heat transfer properties and the use of finned tubes.

Other advantages derived from the use of aluminum: more efficient heat exchange, increased corrosion resistance, reduced maintenance costs and "potential lower material and manufacturing costs."

(more Materials at Work on p 194)

Brearley Co.

Bathroom scale—Cited for honorable mention in the recent Bachner Award Competition, this unit uses injection molded ABS (acrylonitrile-butadiene-styrene) for the housing. *Reason:* the sloping surfaces, finely detailed areas and unusual radii "could not have been produced in die stampings normally used for metal bath scale housings." Other award winning entries on p 12.

MATERIALS AT WORK

Phenolic Laminate Replaces Redwood

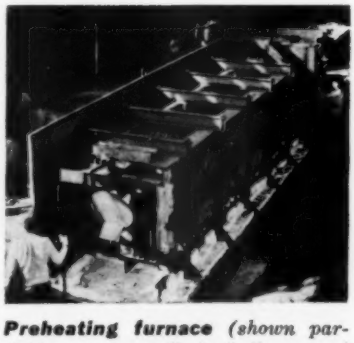
Three problems in the design of high voltage power line hoods have been solved by the switch from oil-soaked redwood to a paper-base phenolic laminate.

Although the redwood parts (which are tubes about 4 ft long and 4 in. in dia) have been used successfully for years, they presented three problems: 1) wood had to be carefully selected and ordered a year in advance so that it could be air dried for several months; 2) processing was extremely cumbersome, involving turning solid blocks on a lathe and then boiling in oil for 10 days; and 3) stresses set up during processing resulted in about 40% waste as a result of cracking.

According to Taylor Fibre Co., the phenolic laminate covers not only eliminate all these steps, but outlast redwood by about two to one, are 25% lighter, and cost about the same. In addition, they offer high dielectric strength and good insulation, low moisture absorption, good toughness, good machinability, and good tensile and impact strength.

'Hot' Shipping Casks Use Clad Steel, Lead

Huge shipping casks with walls consisting of 8½ in. of lead sandwiched between ½-in. thick plates of stainless-clad carbon steel are being used to transport fissionable materials and radioactive waste over normal shipping routes without ra-



***Preheating furnace** (shown partially constructed) is built around cask to control lead's rate of cooling.*

FRASSE ALUMINUM

helps tell how she's doing!

Ballistic missile success hinges on intelligence obtained in test firings. Tracking data – reporting velocity, direction, altitude, temperature, etc. is vital – when processed, it guides critical design changes.

Heart of the intricate data processing system at Cape Canaveral is a Potter Magnityper – a high speed electronic printer that decodes raw material . . . then stores, collates, interprets and prints at 72 *thousand* characters per minute. Lightweight, non-magnetic aluminum is essential to its efficient operation – that's why the Magnityper is made almost completely of Frasse aluminum.

Frasse ships the required sizes quickly from stock – in the grades that contribute to its ease of fabrication *and* performance. For example, Frasse supplies 2024-T4 bars for *strength* and *machinability*, 5052-H34 sheet for *formability* and *weldability* and "775" tooling plate for *dimensional accuracy* with *no distortion when worked.*

Perhaps these same qualities can increase the efficiency of *your* product – or reduce fabricating costs. It's worth investigating – and a Frasse aluminum specialist will be glad to help. There's no obligation – simply write or call your nearest Frasse office. You'll be glad you did.

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WAlker 5-2200	BAldwin 9-9900	BEdford 4700	HOward 3-8655	JAckson 9-6861

For more information, turn to Reader Service card, circle No. 413

diation danger.

To make the casks, a box of stainless-clad plate is suspended within another box of similar material and the 8½-in. space between the boxes is filled with chemically pure lead. According to O. G. Kelly & Co., the finished cask provides good rigidity, strength and radiation shielding properties.

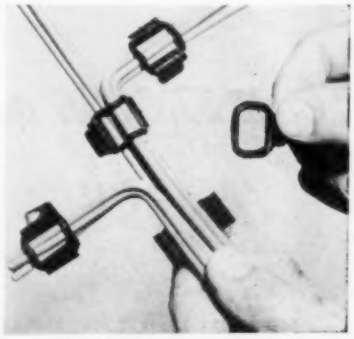
Stainless-clad carbon steel was selected for the chief structural material because the stainless on one surface offers good corrosion resistance properties while the carbon steel on the other is capable of receiving a bonded lead coating. In addition, stainless-clad's heat transfer properties are superior to those of solid stainless.

Nylon, Fluoroelastomer Combined in Fastener

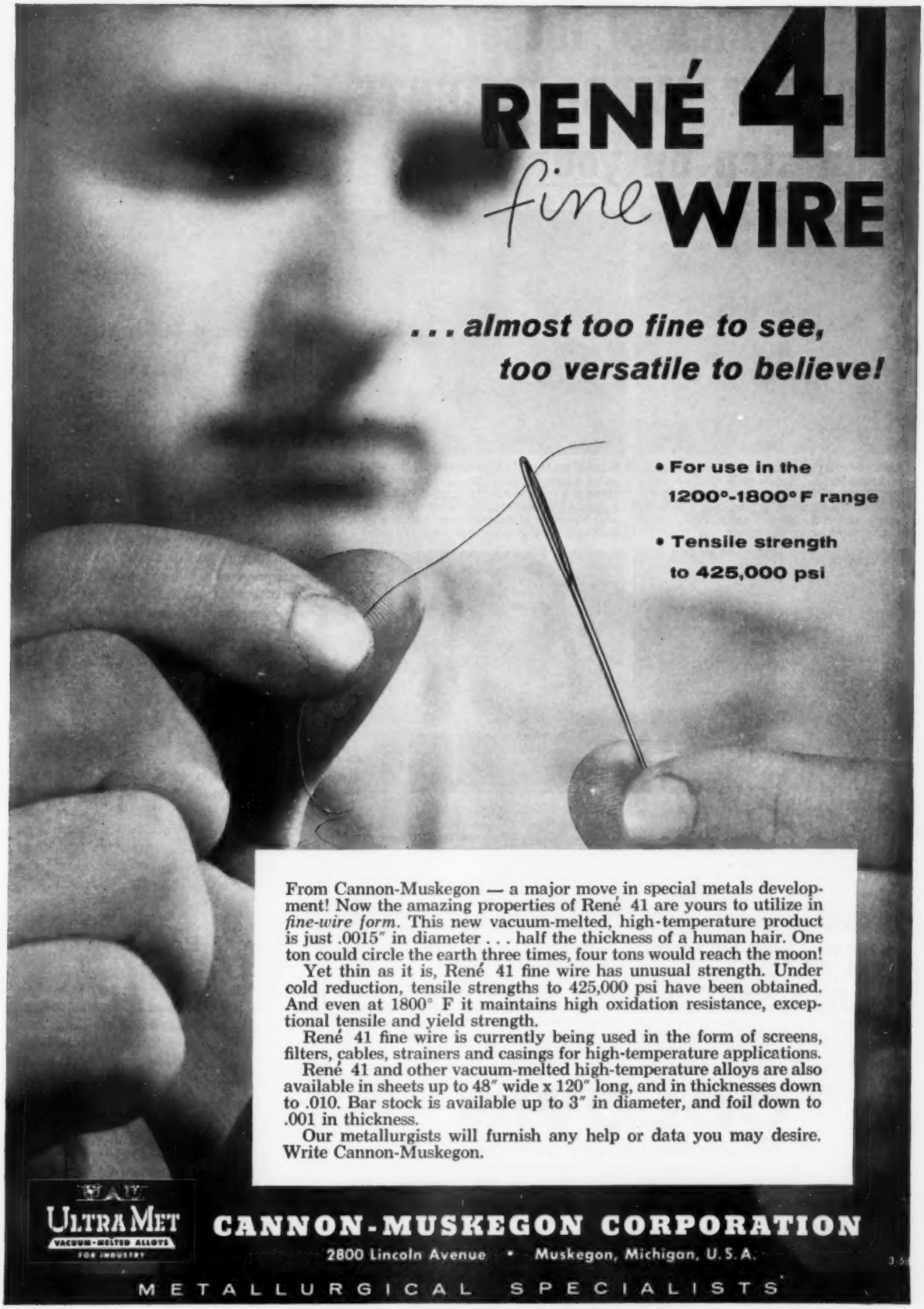
A fastener consisting of a U-shaped nylon cradle and a flexible clip of Viton (Du Pont's fluoroelastomer) has solved a high temperature wire fastening problem in missiles and high speed aircraft.

As shown in the accompanying photo, the Viton clip cinches across the open end of the nylon cradle and locks under inverted lips, holding a bundle of wires securely in place. Originally, the flexible clip was designed for neoprene. However, temperatures up to 300 F and the presence of lubricants, aromatic fuels, hydraulic fluids, etc., dictated the use of a more heat and corrosion resistant material.

According to Du Pont, not only



***Wiring fasteners** are neat, easy to install.*



does the new fastener resist fuels, oils, sunlight, etc. at high temperatures, but it is neater, more secure and less troublesome to install than previously used tape, string or wire wrapping.

Titanium Tubing Used to Heat, Cool Acid

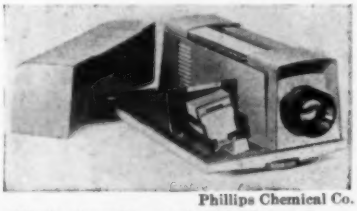
The use of titanium tubing has solved a difficult problem in the design of a system for in-tank heating and cooling of chromic acid plating solutions.

Several other materials were considered: lead tubing had the necessary corrosion resistance and was easily formed, but was so ductile that it required considerable support to prevent bending; steel tubing was found to be undesirable for extended use because the walls eventually corroded and the fittings (usually cast iron) corroded rapidly; tantalum tubing satisfied all requirements but proved disadvantageous because of uncertainty of supply.

According to Superior Tube Co., the titanium tubing was selected because it is readily available and offers the required combination of properties: ability to withstand 25% chromic acid solution, ability to transfer heat readily, ability to withstand steam and water pressure of 15 and 100 psi respectively, and ability to be bent into a "U" without cracking.

Linear Polyethylene Used in Projector

The special characteristics of high density polyethylene—rigidity, heat and impact resistance, electrical insulating qualities, ease of fabrication, glossy appearance and avail-

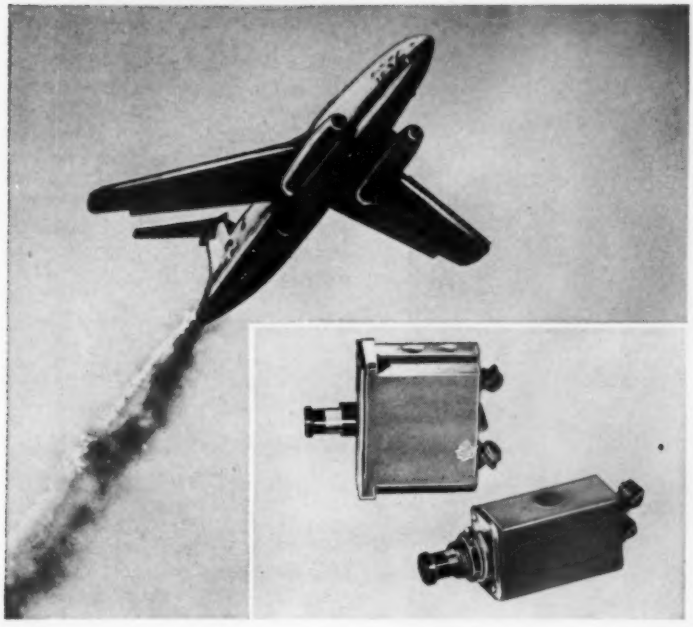


Phillips Chemical Co.

***High density polyethylene** housing is guaranteed for life.*

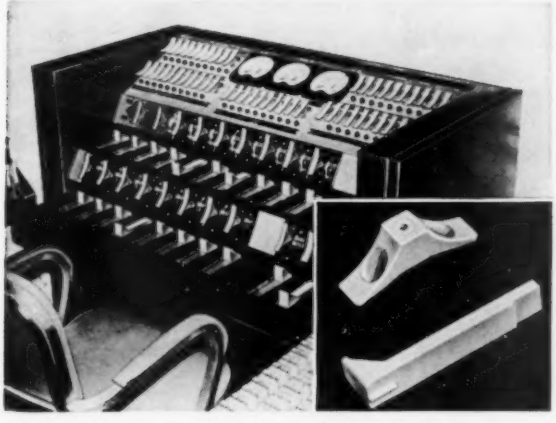
CYANAMID

PLASTICS IN ELECTRICAL DESIGN



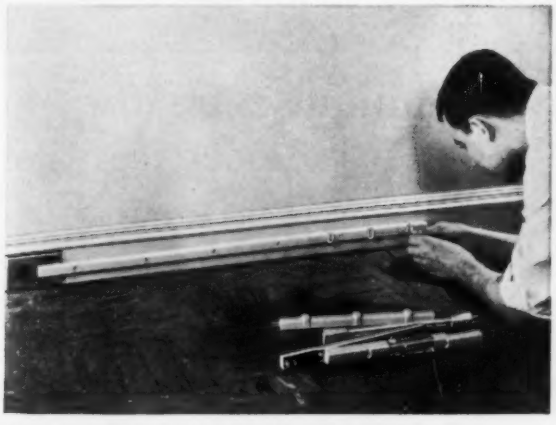
An Ounce of Protection

KLIXON precision aircraft circuit breakers have to be light; yet even the smallest, weighing about 1¼ ounces, can safely interrupt a 120-volt ac, 400-cycle circuit delivering over 4000 amperes. To provide the high arc resistance and great physical strength required, Spencer Thermostat Div., Metals and Controls Corp., uses glass-filled CYMEL® melamine plastic housings. These non-corrosive housings are excellent insulators and stand up to impact, humidity, dust, temperature extremes and fire.



Plastic Keys Conduct Orchestra of Light

The Lumitron Lighting Control System permits one operator to play infinite variations in stage-lighting effects using handles and slide bars molded of BEETLE® urea plastic. BEETLE, an excellent dielectric, requires no insulation. Molded-in colors are permanent, permit quick circuit identification for console operator. Developed by Metropolitan Electric Manufacturing Company, the Lumitron has an excellent record of dependable performance.



New Low-Cost Electrical Outlet System

Made of ivory-colored BEETLE urea molding compound, new interlocking foot-long units provide low-cost, easily installed electrical outlet extensions. BEETLE combines good mechanical and dielectric properties for safe, dependable service, meeting ASTM Specifications D705-49, Grade I. Made by Cable Electric Products, Inc., this new Snapit Inter-Link System is fully approved by Underwriters Laboratories, Inc.

CYANAMID

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
34M Rockefeller Plaza, New York 20, New York

In Canada: Cyanamid of Canada Limited, Montreal and Toronto
Offices in: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • Minneapolis • New York • Oakland • Philadelphia • St. Louis • Seattle

For more information, turn to Reader Service card, circle No. 481

MATERIALS AT WORK

ability in a wide range of colors—are used to advantage in a new semi-automatic slide projector.

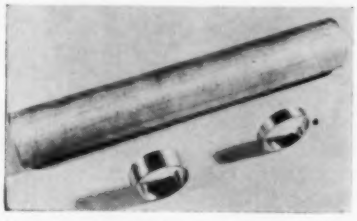
The projector, manufactured by Optics Mfg. Corp., uses high density polyethylene for the housing. Other materials were tested: one, a "high heat resistant" plastic, cracked in several places in a drop test; another, a "high impact" plastic, melted after only four hours in a heat test.

According to Optics, the projector housing is guaranteed not to chip, dent, crack or break.

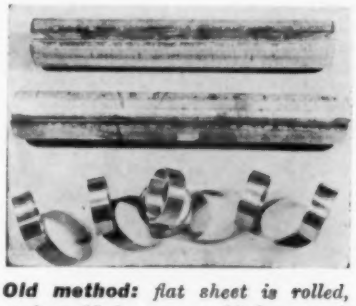
Welded N-155 Tubing Replaces Rolled Sheet

The switch from flat stock to welded tubing has eliminated five time-consuming steps and expensive materials waste in the fabrication of N-155 superalloy connector rings for aircraft turbines.

According to Wright Aeronautical Div., Curtiss-Wright Corp., the previous method involved rolling lengths of flat stock, clamping, tack welding, seam welding, grinding, cutting rings, and sizing the completed rings. This method was expensive because,



New method: *ring of proper width is simply cut from welded tubing and deburred.*



Old method: *flat sheet is rolled, tack welded, seam welded, ground, cut and sized.*

For more information, circle No. 498 ➤

HOW ROYALITE SOLVES 3 BASIC DESIGN PROBLEMS:

TOUGHNESS * BEAUTY * ECONOMY

Leading truck and trailer makers choose damage-free Royalite refrigeration panels that are easy to keep kitchen-clean . . . maintain stable temperature . . . keep weight at a minimum . . . and reduce cooling costs.

Royalite, most versatile of thermoplastic sheet materials, has proven itself time and again to scores of manufacturers . . . in hundreds of varied applications. **Toughness:** Tote boxes of Royalite have built-in resistance to hard knocks. Seamless, easily cleaned, no sharp edges to snag or splinter, quiet, impervious to oils, grease and most chemicals, really lasts. **Beauty:** luggage of Royalite allows modern concepts in molded designs . . . lightweight, pleasing textures, wide range of built-in colors, impact, scuff, and dent resistant, easily cleaned, lasts longer in travel. **Economy:** picnic cooler with pure white Royalite liner provides a non-conductor material with built-in thermal breaker at no extra cost . . . seamless, easily cleaned, odorless, can't rust, deep drawn, modest equipment and labor costs, fabricating techniques permit use on popular priced items. Find out how you can benefit from U.S. Royalite. Let one of our plastics engineers call on you. There is no obligation. Write for information.

Tote boxes by United States Rubber, *Luggage* courtesy of Crown Luggage Co., *Picnic Cooler* courtesy of Coleman Co. Inc., *Refrigeration Panels* courtesy of Trailmobile, Inc.

US Royalite® A.B.S. THERMOPLASTIC SHEET

US RUBBER **United States Rubber**

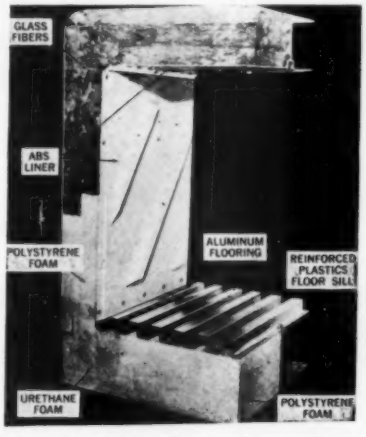
in addition to the time involved, material scrap ran high and many of the completed rings split during final sizing as a result of inclusions and voids in the closure weld. In addition, available equipment for rolling and welding limited the length of tubes to 15 in.

By using 20-in. lengths of welded tubing, Wright Aeronautical reduced operations to cutting rings of the proper width with a wet wheel and deburring. Materials costs were reduced because there is virtually no waste and no splitting during sizing.

Five Materials Combine for Better Insulation

Polystyrene foam, urethane foam, glass fibers, glass-reinforced polyester resin and an ABS (acrylonitrile-butadiene-styrene) liner are combined in what is said to be a more efficient insulation for refrigerated trailers.

According to Brown Trailer Div., Clark Equipment Co., each of the materials performs a specific function: the moisture resistant polystyrene foam is used in areas where condensation is a problem; the closed-cell, foamed-in-place urethane is used to bond the polystyrene and to fill voids; the glass fibers are used to insulate upper sidewalls and ceiling; the glass-reinforced polyester is used



Cross section *shows where each of the five different insulation materials are used.*

Why the new interest in flame retardance of plastic laminates?

Sheet of Synthane to which blowtorch is being applied

While it is unlikely you will ever take up your blowtorch to sample the flame resistance of laminated plastics, this property emerges as a lively topic for discussion among engineers.

Admittedly its import is for the councils of those whose equipment is flame-exposed or is powered, amplified or controlled by vacuum tubes and upon which, clustered or confined, you could properly fry an egg.

Under the circumstances, it is appropriate to ask what laminated plastics (or Synthane, to name our choice) have to offer in the way of flame retardance, and how this property relates to the other, and more widely used, advantages of laminates.

Two Specific Flame Retardant Laminates

There are two grades of Synthane laminates specifically earmarked for flame retardance—Grades FR-1 and FR-2. Except for its flame retardance, Grade FR-1 closely resembles standard paper base phenolic Grade XX Synthane. Grade FR-2 is similar to Grade FR-1, but may be readily hot punched and would be used where flame retardance with emphasis on punchability was desired.

Many Grades of Synthane Self Extinguishing

Many standard grades of laminates—though they contain no flame retardant additives—are self extinguishing. That is, they do not support combustion when the flame is removed.

For example, the fabric and glass melamine grades are excellent for their self-extinguishing characteristics. The same is true of the asbestos grades. Why, then, special flame retarding grades? The answer is partly financial.

The flame retardant grades FR-1 and FR-2 offer good electrical and mechanical properties (similar to Grade XX) plus excellent flame retardance and at a moderate cost. When the electrical or mechanical requirements are severe it is they that may control the choice of laminate even though flame retardance is still necessary. And it just so happens that the cost of producing grades with superior electrical and mechanical properties tops the cost of producing flame-retardant Grades FR-1 and FR-2.

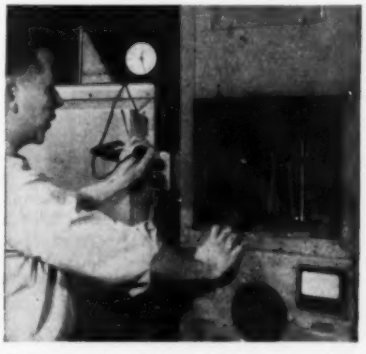
Comparison of Properties of Synthane Laminates with Relation to Flame Retardance

	GRADES										
Property	FR-1	FR-2	XX	C	L	C-M	L-M	G-5	G-8	A-M	AA-M
Flame Retardance	E	E	P	P	P	E	E	E	E	E	E
Heat Resistance	F	F	P	P	P	G	G	E	E	E	E
ARC Resistance	P	P	P	P	P	E	E	E	E	E	E
Mechanical Strength	F	F	F	G	G	G	G	E	E	G	G
Dimensional Stability	F	F	F	F	F	G	G	E	E	E	E
Moisture Resistance	E	E	G	G	G	G	G	E	E	E	E
Dielectric Strength	E	E	G	F	F	F	F	E	E	F	F
Machinability	E	E	E	E	E	E	E	F	F	F	F
Cost	Lowest	Low	Lowest	Low	Mod	Mod	Higher	Higher	Mod	Lowest	Higher

E = Excellent, G = Good, F = Fair, P = Poor

Obviously there is more to this business of selecting an electrical insulation than flame retardance. In any spot where flame retardance is a factor it is prudent to counsel with us, directly or through our representatives, to secure for yourself the Synthane Grade which supplies *all* of the properties you need *in combination* and at a reasonable cost. Our aim is to help you obtain the most for your money so that you may find coming to us a profitable habit.

For further information about Synthane standard or flame retardant grades write Synthane Corporation, 3 River Road, Oaks, Pa.



Flame retardant test on Synthane for switchgear application. Heat is supplied by coil encircling the sample. Temperatures up to 1600°-1800°F are measured with optical pyrometer.

SYNTHANE

CORPORATION, OAKS, PENNA.

Laminated Plastics for Industry

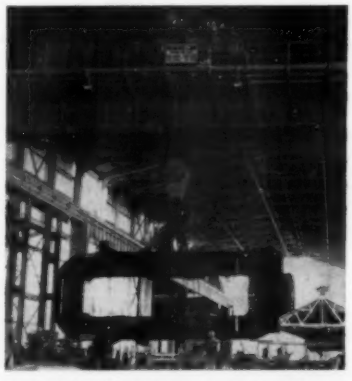
Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

for the floor sills to permit insulation to be installed between these members rather than on the top face as was previously done; and the ABS interior liner provides a lightweight surface that is completely impervious to moisture.

Large Heat Exchanger Uses 6 Miles of Tubing

Six miles of stainless steel tubing are used in what is believed to be one of the largest heat exchangers ever built. According to Thermal Research and Engineering Corp., the four-stage exchanger is used to raise the temperature of 560 lb of air per sec from 350 to 700 F in a gas turbine aircraft engine test program.

More than 400 U-shaped lengths of 1¼-in. o.d., type 321 welded stainless tubing are used in each stage. Air enters the inlet header of each stage, picks up heat from six high velocity oil burners as it passes through the hot tubing, and flows out through the discharge header. Combustion products have a velocity



Largest aluminum crane—Shown in the photo above is what is claimed to be the world's largest overhead aluminum crane. It is shown being used to move a 200-ton housing. The crane has an overall width of 32 ft and a span of 80 ft, and is fabricated from ½-in. and ⅝-in. thick 5083-H113 aluminum plate. According to Reynolds Metals Co., the crane is 50 tons lighter than it would be if made of steel.

Aluminum or zinc clad steel by production metallizing

- *any shape or size*
- *unlimited thickness*
- *no heat distortion*

Modern metallizing provides the product engineer with an extremely flexible, practical method of producing aluminum or zinc clad steel parts. High speed, automated metal spray equipment applies these coatings to practically unlimited thicknesses on any shape or size part without heat distortion.

a typical example

problem: **provide uniform heat distribution on thin steel shell**

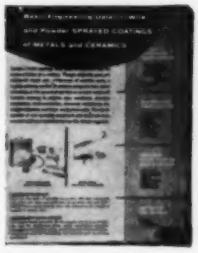
The excellent sanitary qualities of stainless steel make it an extremely desirable material for cooking utensils. But with the comparatively thin, drawn shells (.020″ to .050″—varying by manufacturer), uniform distribution of heat presents a problem.

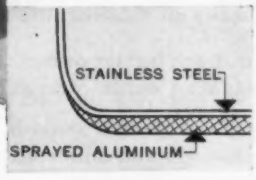
The solution is being provided for a number of high-volume manufacturers by metallized aluminum. Surface preparation is by grit-blasting as the shells rotate on a spindle. Metco Aluminum is then sprayed on the bottom, with automated traverse equipment, to closely controlled thicknesses (from .040″ to .120″, depending on the particular utensil and its manufacturer). The sprayed aluminum is carried up the sides beyond the radius and is tapered off according to individual design.

This is but one of many solutions to fabrication problems offered by sprayed metals to design engineers. In addition to the aluminum example given, zinc is also commonly used for corrosion-proofing in many production applications, such as steel capacitor cases, refrigerator parts, pole line hardware, etc. Sprayed zinc is also used to replace coatings burned, threaded, or machined off during fabrication.

For a round-up of some typical applications and engineering data on the characteristics of metallized coatings, write for Bulletin No. 136-A.

FREE BULLETIN ▶





METCO—Reg. U.S. Pat. Off.

Metallizing Engineering Co., Inc.
1175 Prospect Avenue, Westbury, Long Island, N. Y. • cable: METCO
Telephone: EDgewood 4-1300
In Great Britain:
METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

Mr. Donald A. Watson
Metallizing Engineering Co., Inc.
1175 Prospect Avenue, Westbury, Long Island, New York

Please send me ☐ Bulletin 136-A

Name Title

Company

Address City State

For more information, turn to Reader Service card, circle No. 371

MATERIALS AT WORK

Carpenter Steel Co.

***Welded stainless tubing** resists corrosion in heat exchanger.*

of 300-500 fps as a result of the 11 million Btu of heat released by each burner.

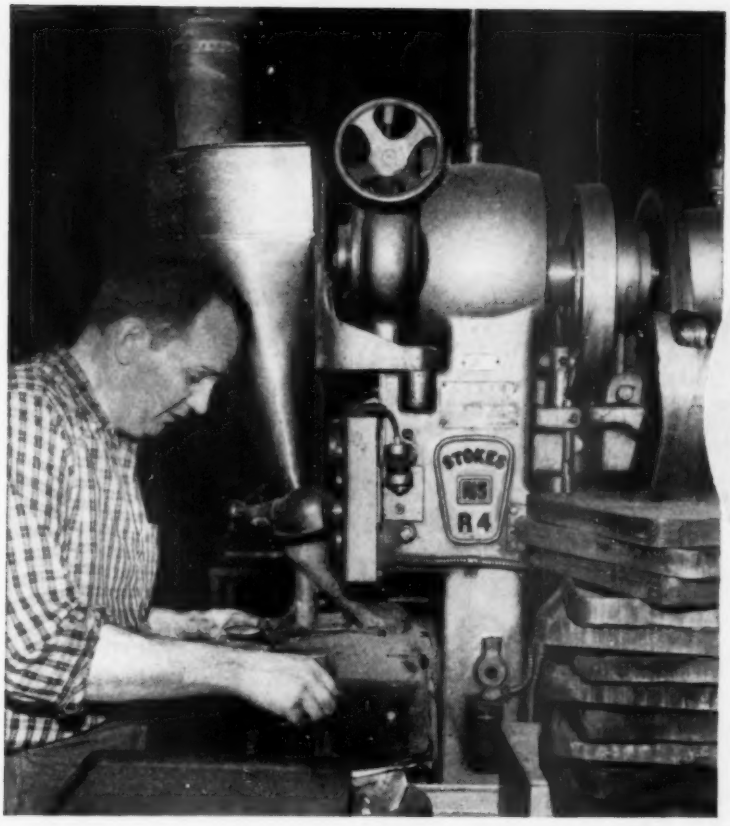
Black Enamel Protects Space Ship at 1200 F

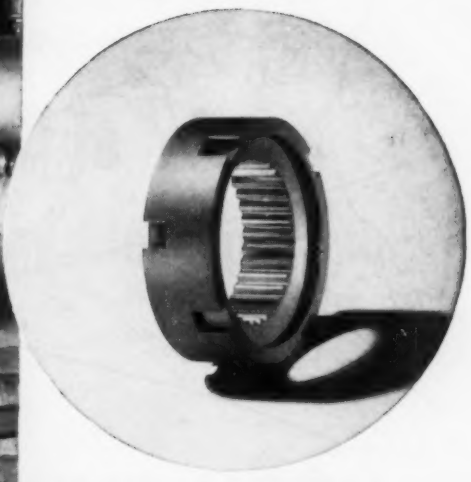
When the Air Force's X-15 rocket ship takes off early this spring in our first scientific attempt to get a man into space and back, its success will depend, to a large extent, upon a special black enamel coating with which its exterior is painted.

According to North American Aviation, Inc., the plane will attempt to pierce the ionosphere (about 100 miles up) and then return to earth. One of the major problems it will have to overcome is the tremendous aerodynamic heating that will occur when the 3600-mph plane re-enters the earth's atmosphere. At some region within the earth's chemosphere (about 40-50 miles above the earth), the leading edges and other portions of the plane are expected to reach a temperature of approximately 1200 F.

According to Rinshed-Mason Co., developers of the special black enam-

SOURCES of most engineering materials can be found in the second edition of M/DE's *Materials Selector* reference issue, published last October. Properties of all materials are also given.





68% SAVINGS were realized on the piece shown above—a tractor part made from an iron base metal powder and having a tensile strength of 65,000 psi and an average hardness of 65 Rockwell B. The part was previously made by screw machine methods. At left, a Burgess-Norton operator checks the output of one of the Stokes R-4 Powder Metal Presses at the company's Geneva, Illinois, plant.

"Quali-SINT"® produced by Burgess-Norton on Stokes powder metal presses

Burgess-Norton Mfg. Co., Geneva, Illinois, is a leading producer of a wide variety of parts by powder metallurgy—including cams, spacers, gears, adapters, ratchets and pawls. The company maintains its own extensive engineering, metallurgical, and chemical laboratories, tool-making, and secondary machining and grinding facilities.

Five Stokes powder metal presses are operated 5 days a week—16 hours a day—to keep pace with their production demands. The number of parts per minute depends on the part and the process being used—only minimum operator attention is required. All 5 presses were chosen by G. W. Waller, Vice President of Engineering, on the basis of "(1)—Production rate per dollar cost, (2)—Minimum maintenance requirements, and (3)—Price."

Continual research and advancement in the field of powder metallurgy has made Stokes the recognized leader in this modern industry. Stokes achievements may well be the answer to meeting your own production requirements economically—and at high speeds. Ask for complete information on the Stokes line of industrial compacting presses—or for assistance by Stokes Engineering Advisory Service. Call—or write—today.

®*"Quali-SINT" is a registered trademark of Burgess-Norton Mfg. Co., Geneva, Ill.*

Powder Metal Press Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

For more information, turn to Reader Service card, circle No. 478

MATERIALS AT WORK

***Manned space ship** is painted with special black enamel to radiate heat of re-entry.*

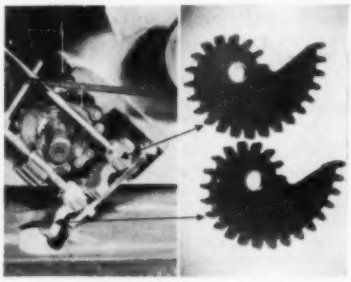
el, concentrated friction of the air at re-entry will cause the heat to build up throughout the entire plane's structure, and the problem is not one of reflecting but radiating the heat away from the surface. Of all colors, black radiates heat fastest.

Die Cast Zinc Replaces Investment Cast Gear

Intricate gears for a copying machine, formerly produced by investment casting, are now being turned out as zinc die castings—with equivalent accuracy at a fraction of the original cost.

The change was made primarily to reduce costs. The parts involved are a pair of identical mating variable-pitch gears, each working from a fixed center (see accompanying photo). The gears contain 23 teeth, each differently shaped: pitch radii range from 0.240 to 0.80 in. All teeth are undercut, and they do not converge to a common center. Tolerances must be held to ± 0.001 in.

According to the American Zinc Institute, the gears are die cast with exact uniformity of tooth shape, radii and angles, and no machining is required. The gears are used in Minnesota Mining & Mfg. Co.'s Thermofax copying machine.



***Variable pitch gears** (right) are accurately produced by die casting.*

Amchem Alodine... industry standard for the jet age ...chemical conversion coatings for aluminum

Jet aircraft fly higher, faster, farther than their piston-engined predecessors. Achieving this obvious superiority will require new levels of consistently maintained protective standards for parts and assemblies. • For that reason, fabricators of aircraft and aircraft parts continue to specify Amchem Alodine. Fifteen years of leadership and experience have made Amchem Alodine the industry standard for chemical conversion coatings for aluminum. Wherever it is used, Amchem Alodine has justified that use by improving the corrosion resistance and increasing paint bonding characteristics of aluminum surfaces. • Whether your activities involve conventional aircraft, jet age aircraft or missiles, it will pay you to investigate how Amchem Alodine produces low cost, more efficient chemical conversion coatings for your aircraft aluminum products.

Write for Bulletin 1424A describing the specific applications of Amchem Alodine. Contains handy Selection Chart to help you choose the Alodine type suited to your needs.

AMCHEM

AMCHEM ALODINE

Amchem Alodine is another chemical development of **Amchem Products, Inc.**, Ambler, Pa. • Formerly American Chemical Paint Company Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont./Amchem and Alodine are registered trademarks of Amchem Products, Inc.

For more information, turn to Reader Service card, circle No. 446

Since World War II designers of air and space craft have made ever-increasing use of honeycomb in a great variety of structural and non-structural applications. Honeycomb can be made from almost any material available in continuous web or roll form, e.g., aluminum, glass fabric, cotton, stainless steel, paper, asbestos, titanium. In its cellular configuration, honeycomb is 97% air, 3% material.

Honeycomb has intrinsic qualities of high strength, light weight, high ratio of surface area to volume and other specific properties which depend upon the type of material used. These combinations of properties, which have given honeycomb wide application in air and space craft, offer to designers in industry generally unique opportunities in product design.

In the interest of advancing this knowledge of honeycomb, Hexcel, through its research and development staff (the industry's largest), has prepared this informational series. Should you desire additional technical information, please complete the information request form on this page. Your request will receive immediate attention.

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept. "M"
2332 Fourth Street, Berkeley 10, California

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE____ STATE_____

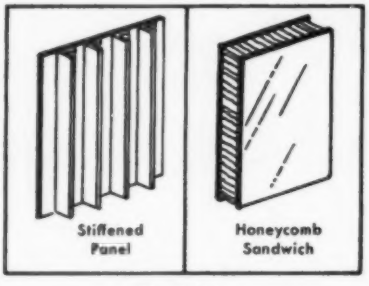
HEXCEL PRODUCTS INC.
World leader in honeycomb

Executive offices: 2332 Fourth St., Berkeley, California. Plants: Oakland and Berkeley, California; Havre de Grace, Maryland. Sales Offices: Inglewood, California; Fort Worth, Texas; Long Island City, New York.

HONEYCOMB SANDWICH PANELS

Strength/Weight Ratio

Traditional design of flat panel structures to resist bending or column loading has been to use either thick plates or thin sheets stiffened with angle extrusions to form a more or less rigid panel. Where end use of panel requires a high stiffness-to-weight ratio or a superior strength-to-weight ratio, many designers have turned to the use of sandwich structure.



Sketch #1

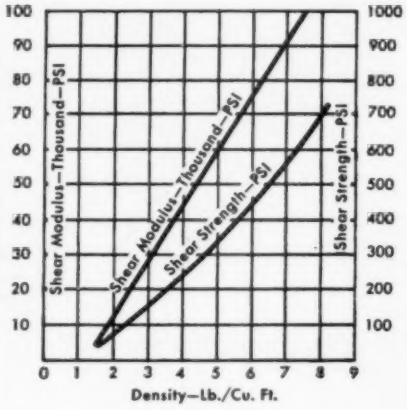
In a sandwich structure, the panel is made up of two faces with a light weight core material between them. In order to qualify as a structural sandwich, the core must be rigidly attached to the two faces. When these requirements are met, the resulting structure is capable of the highest strength-to-weight and rigidity-to-weight ratios presently obtainable by ordinary design methods.

Sandwich Structures:

A Design Approach

Sandwich structures are really a method of design approach rather than a single material. It is possible to design structures precisely tailored to fit the requirements at hand. Not only can the thickness and type of facing material be varied, but the thickness and density of the core material is subject to the designer's choice.

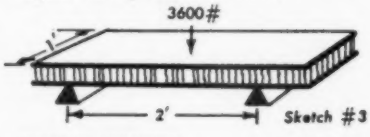
In the two curves shown, shear strength and shear modulus are given for Hexcel aluminum honeycomb in densities ranging from two to eight pounds per cubic foot. The strengths these core materials develop compare favorably with the strength of much heavier cores of plastic foam, wood fibers or other less efficient materials.



Sketch #2

Bending Loads

Bending strength and the bending rigidity of sandwich panels are two primary reasons for their broad acceptance in the area of light weight structures. In comparing panels loaded as shown in the sketch below, it can be shown that honeycomb sandwich is by far the lightest of any usable structure.



Sketch #3

3600 LB. WEIGHT - - - - - 24" SPAN

Material	Deflection (in inches)	Weight (in pounds)
Honeycomb Sandwich	.058	7.79
Nested "I" Beams	.058	10.86
Steel Angles	.058	25.9
Aluminum Plate	.058	34.2
Magnesium Plate	.058	55.0
Steel Plate	.058	68.6
Glass Reinforced Plastic Laminate	.058	83.4

The list of weights and deflections in the above table gives a clear indication that honeycomb sandwich panels have broad areas of application.

For more information, turn to Reader Service card, circle No. 506

Design Show

Reminder: the 4th annual Design Engineering Conference and Show will be held May 25-28, Convention Hall, Philadelphia.

This year's Conference, sponsored by ASME's Machine Design Div., will cover latest developments in plastics, metals and ceramics for 1000 F service; and latest developments in materials and coatings to resist corrosion.

The Show, sponsored by Clapp & Poliak, Inc., will feature displays of the latest metals, nonmetallics, fasteners and adhesives, finishes and coatings, and shapes and forms.

For complete details on registration, technical program and exhibitors, see May issue of M/DE.

Fundamental Study of Materials Aim of New ASTM Division

The growing awareness that the same fundamental concepts underlie the behavior of all materials is largely responsible for the establishment by the American Society for Testing Materials of a new division. Its purpose will be to intensify the development of knowledge of the fundamentals of materials. The Society will also sponsor a special symposium on materials education.

Structure is key

According to the Society, the new division will concern itself with the collection, establishment and publication of basic information essential in creating a better understanding of materials and their properties, and especially, to help answer "why" materials are what they are.

The approach to the problem will be to provide a forum for materials scientists and engineers whose activities cut horizontally across the entire materials field. Physicists, chemists and engineers (mechanical, electrical, chemical, etc.) will channel their energies in the direction of trying to relate knowledge of the underlying structure of one material, or one class of materials, to an understanding of all materials.

Materials education

A secondary problem, but one which will become increasingly vital as our advancing technology creates severe new service requirements, is how engineering materials can be taught to engineering students. To explore this problem, ASTM and the American Society for Engineering Education will jointly sponsor a symposium on "Education in Materials" at the ASTM's annual meeting scheduled for June 22-26 in Atlantic City.

The symposium will include a talk by Kenneth B. Woods, ASTM president and head of Civil Engineering at Purdue University; Frank L. LaQue, ASTM senior vice president and vice president and manager of the Development and Research Div., International Nickel Co.; and Dean William T. Alexander, Northwestern

Powder Metallurgy Show — See pp 21-23 for complete details on registration, technical program and exhibitors at the 15th annual MPI Meeting and 1959 Powder Metallurgy Show, Apr 20-22, Detroit.

University and president of ASEE.

Requirements in materials education from the point of view of industry will be discussed by two speakers representing the nation's leading industries. The symposium will be concluded by a survey of projected degrees in materials engineering now being considered or initiated in many engineering schools.

Special Courses Cover Engineering Materials

Recognizing the ever-increasing need for more highly trained materials engineers, many of the nation's leading colleges and universities have developed special courses, seminars, symposia, etc. concerned with the selection and use of engineering materials. From time to time, the editors of M/DE will prepare and publish brief reports on these special courses. Following is one such report:

New York University—Vacuum Metallurgy (June 1-2); **Thermoelectric Materials:** a series of lectures on latest theories, materials and devices (June 15-19); **Ductile Iron:** lectures and a panel discussion by experts from industry and research laboratories on the technology of ductile iron (June 29-July 3); **Titanium Metallurgy:** annual conference on recent advances (Sept 14-15).

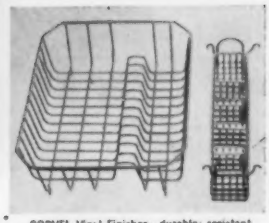
Pennsylvania State University—Machinability: seminar on fundamental theories, new developments, methods and techniques, machinability of high temperature and hard alloys, and practical applications of metal cutting research (June 7-12); **Plastics:** complete summary of plastics engineering and information on new plastics, new techniques and new applications (June 28-July 3).

Massachusetts Institute of Technology—Corrosion (June 22-26); **Materials for Parachute and Retardation Devices** (July 20-31).

University of Notre Dame—Sintering and Related Phenomena: conference composed of chemists, engineers and physicists, designed to effect an exchange of ideas on sintering in general and on phenomena, such as diffusion plastic and viscous flow,

CORVEL† Fusion Bond Finishes—

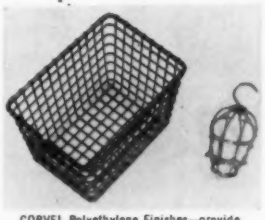
CORVEL Cellulosic Finishes—tough decorative finish retains color and gloss when exposed to water, salt spray, sunlight.



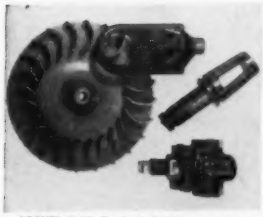
CORVEL Vinyl Finishes—durable; resistant to corrosion and most chemicals. Available in a range of colors.

CORVEL Epoxy Finishes—excellent insulation at elevated temperatures; moisture, chemical and impact resistant.

CORVEL Nylon Finishes—to impart the outstanding wear and low frictional qualities of nylon to metals.



CORVEL Polyethylene Finishes—provide zero water absorption, excellent chemical resistance and electrical insulation.



CORVEL K-51 Penton* Finishes—exceptional chemical and wear resistance. Withstand temperatures from —40°F. to 250°F.

*Trademark of Hercules Powder Co.

Six new resins that broaden the possibilities of product design

● Now a unique method for cladding opens the way for new developments in product design. CORVEL Fusion Bond Finishes are specially processed dry resin powders for use in the solvent free, patented* fluidized bed coating process. Greater beauty and improved durability are achieved because these finishes provide the following advantages:

- Single dip treatment with comparatively heavy finishes (normally 0.008″ to 0.025″).
- Eliminates sag and drips, no bridging or irregularities in material flow.
- Excellent coverage of sharp edges, corners and projections.
- Uniform, non-porous coatings having good adhesion provide excellent resistance to corrosion and mechanical abuse.

Process licensing is now readily available. A process license is automatically extended to the purchaser of CORVEL powders from National Polymer Products, Inc. upon payment of a small royalty added to each sales invoice. General licenses to use the patented process are available from Polymer Processes, Inc., an affiliate company.

Technical service is available to help licensees achieve the greatest benefits from CORVEL resins and the fluidized bed process and equipment. Write for further details and the new full-color CORVEL bulletin.

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Design Engineering Show, Philadelphia
May 25 to 28

NATIONAL POLYMER PRODUCTS, INC. / Reading, Pennsylvania
West Coast Facilities: The Polymer Corporation, Santa Ana, California

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†Polymer Corporation trademark for finishing materials
*U.S. Patent 2,844,489 and over 30 patents pending

For more information, turn to Reader Service card, circle No. 531

creep, surface physics, crystal growth, etc. (June 15-17).

West Virginia University — Underground Corrosion: fundamentals of corrosion, theory and application of cathodic protection, various coatings, field practices, corrosion resistance of cast iron pipe, expendable anodes, etc. (June 2-4).

Boston College—Industrial Spectrography: use of emission spectrography as an analytical tool. (July 20-31).

University of Wisconsin—Adhesives and Fasteners: adhesives session covers properties, methods of application to various materials, and surface preparation; **fasteners** session covers snap, sealing, friction, quick-action, and vibration-proof fasteners (May 7-8); **Plastics:** new plastics materials, their properties, and how and where they can be used profitably (May 26-27).

University of Michigan—Application of Stress Analysis to Design and Metallurgy: principles and methods of applying stress analysis to the problems of engineering design, materials specification, and service failure; covers static, fatigue and impact loading; notch sensitivity and stress concentration; size effect, surface finish and hardening (Aug 24-28); **Modern Approach to Machining Problems:** fundamentals of metal cutting, and latest advances and concepts in machine practice.

Five Technical Groups to Meet This Month

Five trade societies will hold meetings on materials during the next four or five weeks:

American Foundrymen's Society (Apr 13-17, Chicago) — Simplified production of castings of unusual design will be emphasized at the 63rd AFS Castings Congress and Engineered Castings Show. All types of cast metals and patterns for casting will be exhibited and discussed at the Show and in the more than 60 separate sessions of the Congress. Some of the subjects to be covered: X364 aluminum die casting alloy, stress concentration and castability, light metal casting, nondestructive testing by radiation, steel casting,

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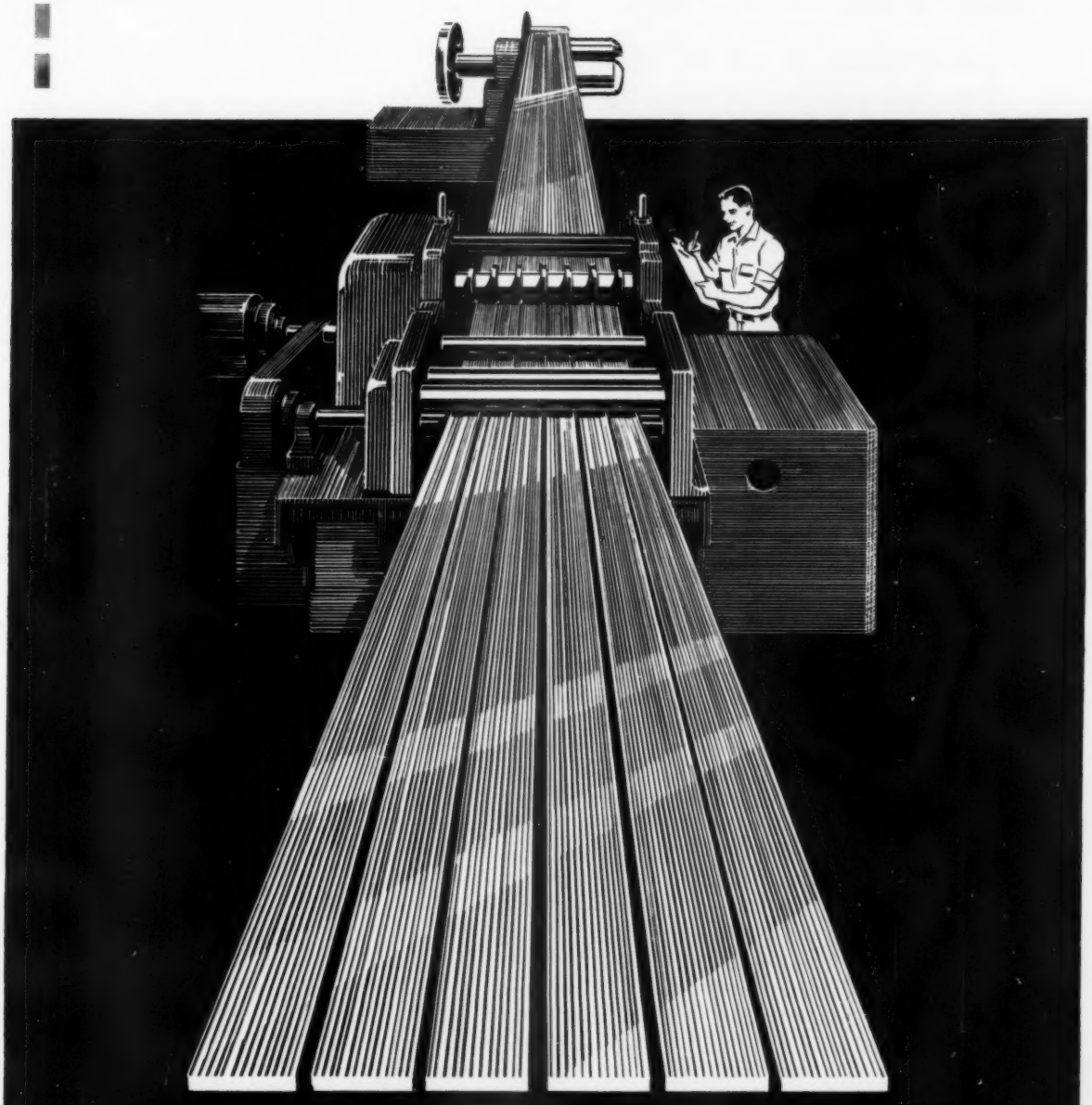

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News OF INDUSTRY

and magnesium casting.

American Society of Tool Engineers (Apr 18-22, Milwaukee)—"Planning for Profit" is the theme around which ASTE's 1959 annual convention will be held. Some of the topics to be covered: metal cutting, welding of tool steel, machinability and cost control.

Institute of Environmental Engineers (Apr 22-24, Chicago)—Some of the subjects scheduled for the third annual technical meeting and equipment show are: shock and vibration, extremes of modern environments, testing problems, standardization and criteria, and damaging effects of radiation.

American Society of Mechanical Engineers (Apr 29-May 1, Albany)—New developments in metals engineering and related fields will be covered in the 24 technical papers scheduled to be presented in a special conference sponsored by the Metals Engineering Div. of ASME. Some of the topics: the challenges of the mechanical engineer to the metallurgical engineer, non-metallic

Automated rolling—Shown above is a portion of what is said to be the first electronically controlled aluminum rolling mill. According to Aluminum Co. of America, the automatic system uses IBM punch cards to establish mill speed and roll opening for a 160-in. reversing mill. The mill rolls 16-in. billets into slabs measuring 3 to 4 in. thick.

Riverside continuous casting saves you production time, cuts rejects

Brass and other copper-based strip, rod, and wire from Riverside produces consistently better end products for you—free of weak points that result in rejected pieces or whole batches.

How do we do it? By *continuous casting*, a process we introduced to this country—a process that eliminates air holes and impurities, leaving a dense, homogeneous casting for better wire-drawing and other fabrication requirements.

Get the full cost-saving story from *Riverside-Alloy Metal Division, H.K. Porter Company, Inc., Riverside, N.J.*

good riddance to "Swiss Cheese" castings!

RIVERSIDE-ALLOY METAL DIVISION PORTER **H.K. PORTER COMPANY, INC.**

DIVISIONS: Connors Steel, Delta-Star Electric, Disston, Forge & Fittings, Leschen Wire Rope, Mouldings, National Electric, Refractories, Riverside-Alloy Metal, Thermoid, Vulcan-Kidd Steel, H. K. Porter Company (Canada) Ltd.

For more information, turn to Reader Service card, circle No. 495

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structural materials, plastic flow and fracture, brittle fracture, creep behavior of metals, high temperature behavior, and fatigue. In addition, a five-man panel will discuss "The Application of Metals in Heavy Sections."

Electrochemical Society (May 3-7, Philadelphia)—Special symposia on liquid dielectrics and on electrode processes, featuring papers by over 25 noted electrochemists from the United States, Russia, Spain, Germany, Italy and England, will be presented at the 115th national meeting of the Electrochemical Society. In addition, technical sessions will be conducted by five of the Society's divisions: Theoretical, Industrial Electrolytic, Electrothermic and Metallurgy, Electronics (Thermionics, Semi-conductors, Luminescence) and Electric Insulation.

International Standards Set on Yard and Pound

The directors of standards organizations representing the governments of Canada, New Zealand, the United Kingdom, South Africa, Australia and the United States have agreed to adopt an international yard and an international pound having the following definitions: international yard = 0.9144 meter; international pound = 0.453-59237 kilogram. The new standards go into effect July 1.

The international inch, derived from the international yard, is exactly equal to 25.4 mm. At present, however, the National Bureau of Standards is using the inch defined by the Mendenhall order (1893): 1 in. = 25.4000508 mm; 1 yd = 0.91440183 m. The inch presently used by the National Physical Laboratory of the United Kingdom is: 1 in. = 25.399956 mm.

The values of the pound currently in use in the U. S., Canada and the United Kingdom are as follows: 1 U. S. lb = 0.4535924277 kg; 1 British lb = 0.453592338 kg; and 1 Canadian lb = 0.45359243 kg.

To avoid confusion during the transition period, National Bureau of Standards calibrations of length or mass expressed in English units will embody a statement indicating

the LEAD newsletter

In last year's New York Times, one small photograph showed an abstract, contemporary sculpture made of metal. It got its color from being painted with red lead. Only a few weeks ago, newspapers carried the story of a new atomic electrical generator developed for use in space vehicles. The semiconducting component is lead telluride. In new products and developments of a startling diversity, for purposes that are sometimes aesthetic but always practical, lead is the element unique, vital and necessary.

Lead Adds Brilliance On Fifth Avenue

Ceramics

In office buildings and stores, lead has proved its uncommon values. It is essential to the production of durable, high-quality porcelain enamels for aluminum, such as those used on panels running the entire height of New York's new Tishman Building. The high fluxing property of lead gives porcelain enamels brilliance and smoothness, increases their elasticity and chemical resistance. The striking facade of Lord & Taylor's newest branch store is brick with a lead-based ceramic glaze which provides the polished surface and the variety of color tones that the designer wanted. Versatile lead compounds help glazes flow freely and form smooth, brilliant coatings. And by melting quickly at relatively low temperatures, they save furnace time and fuel.

Leaded Steels

Take lead in combination with steel. Leaded steels have made lower costs possible because lead increases machinability. Cutting rates jump by 35 to 50 percent, with longer tool life. One large steel manufacturer advertises that leaded steel tubing . . . made from "the world's fastest-machining steel"... promises a *minimum* increase of 25% in productivity! Leaded-steel bars from the same company are said to average a machining speed of 375 surface feet per minute.

Heavy Construction

The industrial use of lead has, on occasion, become an official rule. Forty seven of the forty nine states specify lead based primer paints for bridge and highway construction and new formulations have been developed to meet special requirements. The New York State Power Authority is using more than 1,000,000 lbs. of sheet lead for the new Niagara Power Project, as a lubricating base and seal between the concrete walls and bottom slab of water-carrying conduits. The lead will cushion the walls, preventing them from being cracked or crumbled by rock squeeze, as well as sealing them against water leakage.

Electronics

Lead is vital to today's most advanced designs for aural as well as visual reasons. Stereophonic sound frequently depends on two small cartridge elements of lead zirconate-titanate, a newly-developed polycrystalline material. And the same material can also greatly increase the operating range of missile devices, sonar transducers, ultrasonic cleaning equipment and many other systems.

Lead Helps Put Sound "In The Round"

Lead is currently the subject of vastly expanded research and development efforts, not only by the lead industry itself, but by government, universities, research organizations and private companies. Its unique combination of properties make it highly adaptable to modern technology as a metal, alloy or chemical compound.

Investigations are under way in ceramic body and finish formulations, gamma ray shielding, building construction design, sound and vibration attenuation, design of chemical processing equipment and many other areas of product development.

If you are presently investigating new products or have product design problems that need solution, why not let us provide you with detailed information about lead and available technical assistance. Write: Office of Technical Information, Lead Industries Association, 60 East 42nd Street, New York 17, New York. 2390

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Lead Industries Association

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For more information, turn to Reader Service card, circle No. 549

News OF INDUSTRY

which unit has been used if the choice introduces a significant difference in calibration values.

The standard U. S. gallon and the Imperial gallon are so substantially different that a compromise international gallon was not practicable. The U. S. gallon is defined as equal to 231 cu in. The Imperial gallon is defined as the volume of 10 lb of water under specified standard conditions. A fairly exact relationship is: 1 Imperial gal = 1.20094 U. S. gal.

Engineers

George J. Godfrey has been appointed technical director, Reed Plastics Corp.

W. B. Moen has been named manager of engineering, Air Reduction Co., Inc.'s newly formed Special Products Dept., Union, N. J.

Raymond T. Zwack is now manager, development engineering, Des Moines Div., Solar Aircraft Co.

E. P. Best has been appointed director of metallurgy and research, and **T. D. Bonner** has been named chief wrought iron metallurgist, A. M. Byers Co.

Cloyd L. Betzer has been named technical manager, Pfaudler Co., a division of Pfaudler Permutit, Inc.

Arthur B. Beetle has been appointed instruments product manager, Milton Roy Co.

Gilbert L. Cox is now technical manager, Whitehead Metals, Inc.

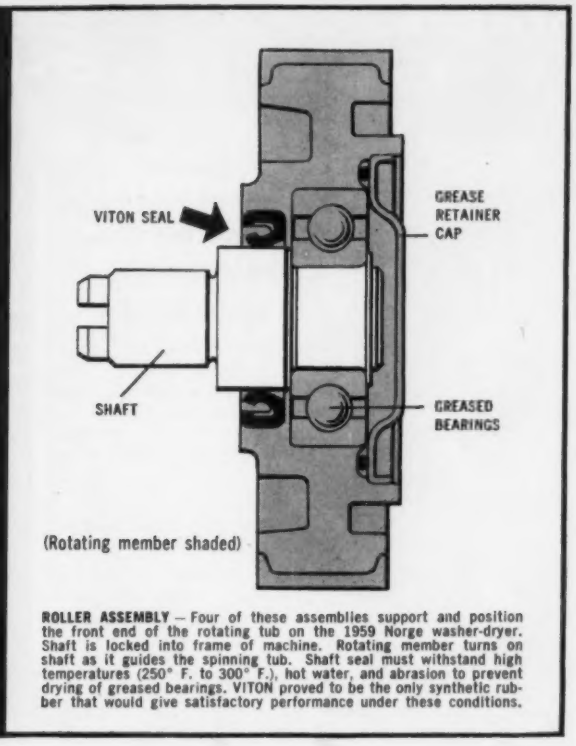
Charles A. Hathaway has been appointed director of engineering, Air Impeller Div., Torrington Mfg. Co.

Dr. Herman S. Kaufman has been named technical assistant, Central Research Laboratory, Allied Chemical Co.

H. W. Lownie, Jr., Battelle Memorial Institute, has been awarded a gold medal by the American Foundrymen's Society for "outstanding contributions to the Society and to metallurgical progress."

Edward A. Loria has been named manager, high temperature and corrosion resistant materials, Metallurgical Development Div., Climax Molybdenum Co.

Richard J. Newman has been appointed general manager of Daven



ROLLER ASSEMBLY — Four of these assemblies support and position the front end of the rotating tub on the 1959 Norge washer-dryer. Shaft is locked into frame of machine. Rotating member turns on shaft as it guides the spinning tub. Shaft seal must withstand high temperatures (250° F. to 300° F.), hot water, and abrasion to prevent drying of greased bearings. VITON proved to be the only synthetic rubber that would give satisfactory performance under these conditions.

On New Norge Washer-Dryer Combination

VITON shaft seal gives best resistance to 300° F. heat, grease, abrasion

VITON TRADEMARK

The rotating tub of the new Norge automatic washer-dryer combination rides on four roller assemblies containing bearings that are permanently sealed in grease (see diagram). These bearings are expected to last as long as the appliance—in spite of hot, dirty detergent water and high temperature air that come in contact with the assembly.

One obvious engineering requirement was the use of a flexible seal between shaft and rotating member of the roller assembly to prevent water and air from attacking the bearings. The *problem* was to find a synthetic rubber that would give good performance in spite of grease, oxidation and abrasion at operating temperatures of 250° F. to 300° F. (Because of soil suspended in the wash water, abrasion was found to be particularly severe where the rotating seal rubbed against the stationary shaft.)

Tests showed that seals made from well-known synthetic rubbers failed at the 300° F. temperatures. Special high-temperature synthetics were inadequate in abrasion resistance. A material was needed that possessed good mechanical properties at high temperatures. Du Pont VITON synthetic rubber was the solution.

A shaft seal made of VITON gave Norge engineers the required resistance to grease, oxidation and abrasion—even at temperatures over 300° F. No other synthetic rubber tested could come near this record. As a result, VITON was adopted, and is now specified for this shaft seal on the 1959 Norge combination.

Learn more about VITON, for gaskets, diaphragms, O-rings, hose, tubing, and molded parts where you need a synthetic rubber with resistance to heat (400-450° F. continuously . . . up to 600° F. intermittently) and corrosive fluids . . . *plus* excellent mechanical properties. Write for complete technical facts to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MM-4, Wilmington 98, Delaware.

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NEOPRENE
HYPALON®
VITON™
ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

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Co.'s newly formed Reliability Assurance Div.

W. R. Manson has been named vice president of research and development, R. D. Werner Co., Inc.

Dr. Kurt S. Konigsbacher is now associate development manager, Evans Research and Development Corp.

Robert Archer has been named development engineer, Greer Hydraulics, Inc.

Dr. Miro A. Grottger has been appointed director of Precision Tube Co., Inc.'s newly formed Research and Development Div.

Dr. Irwin I. Bessen has been named research supervisor of the physical metallurgy section, Research and Development Dept., Jones & Laughlin Steel Corp.

Archie C. Anderson has been named technical director, Reinforced Plastics Div., A. O. Smith Corp.

D. M. McDowell has been appointed director of engineering, Roots-Connersville Blower Div., Dresser Industries, Inc.

Kenneth G. Hookanson has been named director of research and development, H. M. Harper Co.

Richard Doughton, Jr., has been named supervisor of product development, Stainless and Strip Div., Jones & Laughlin Steel Corp.

Eric G. Boehm has been appointed assistant general manager, Buffalo Bolt Co., a division of Buffalo Eclipse Corp.

Dr. C. E. Oelker has been named director of engineering, Cincinnati Div., Bendix Aviation Corp.

Gordon Turnbull is now vice president and works manager, Marvel-Schebler Products Div., Borg-Warner Corp.

J. Walter Guyer has been named vice president and director of research, Conap, Inc., Olean, N. Y.

Harry E. Gravlin, Jr., is now production manager, Hamilton Standard, a division of United Aircraft Corp.

J. F. Thorne has been named manager of engineering services, Continental Can Co.

H. W. Mohrman has been appointed director of research-associated interests, and **Dr. R. J. Schatz** has been named director of research, Plastics Div., Monsanto Chemical Co.

Ralph M. Knight has been named manager, polyolefin planning and ap-

News of Industry

plications, U. S. Industrial Chemicals Co., a division of National Distillers and Chemical Corp.

Eugene J. Hochdanner has been appointed chief engineer, Latrobe Steel Co.

Dr. Cosimo Torre has been named research associate, M. W. Kellogg Co., a subsidiary of Pullman Inc.

Donald R. Hepler has been named vice president of manufacturing, Cooper Alloy Corp.

John T. Castles has been appointed manager, chemical development operation, General Electric Co.

Dr. Albert L. Elder, Corn Products Co., has been elected president of the American Chemical Society for 1960.

John L. Pfeffer, Struthers-Dunn, Inc., has been elected president of the National Assn. of Relay Mfgrs.

Companies

Research Specialties Co. has moved to a new plant at 200 S. Garrard Blvd., Richmond, Calif.

Phoenix Steel Corp. is the new name for **Phoenix Iron & Steel Co.,** a subsidiary of Barium Steel Corp.

National Cylinder Gas Div., Chemetron Corp., has established new regional headquarters at 2191 S. Green Rd., Cleveland, Ohio.

High Voltage Engineering Corp. will expand its Burlington, Mass. facilities by 20%.

McGregor-Michigan Corp. has moved to new quarters at 13360 Helen Ave., Detroit 12.

Vanguard Products, Inc., has moved to new quarters at 19 Crawford St., Newark, N. J.

Almetco, Inc., is a newly formed company owned jointly by Olin Mathieson Chemical Corp. and Textron, Inc.

AviSun Corp. is a newly formed, equally owned affiliate of American Viscose Corp. and Sun Oil Co. Offices of the company, a supplier of polypropylene, are located at 1608 Walnut St., Philadelphia 3.

E. I. du Pont de Nemours & Co., Inc., has begun operations in a new multi-million-dollar sodium and chlorine unit at its Memphis, Tenn. plant.

Thermix Corp., Greenwich, Conn., has purchased **Heacon, Inc.,** which

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FORMULATING

particularly in areas
such as:

ADHESIVES BODY SOLDERS
CASTING COATINGS
IMPREGNATING
LAMINATING TOOLING

the U. S. and Canada, CIBA produces basic resins only

CIBA Products Corporation, Kimberton, Pa.

☐ Please send me complete technical information on Araldite Epoxy 6005. MIDE4-1

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will be operated as a wholly owned subsidiary of Thermix.

Shell Development Co.'s Emeryville Research Center has formed two new departments for synthetic rubber and thermoplastics, with Drs. N. R. Legge and F. E. Condo appointed department heads, respectively.

Carborundum Co. plans to build a new ¾-million-dollar pilot plant at its Research and Development Div. in Niagara Falls, N. Y.

American Metal Products Co. has acquired **Davis Engineering Corp.**

Extrudo-Film Corp. has begun constructing a 50,000-sq ft plant in Pottsville, Pa. for the production of polyethylene film, sheet and tubing.

American Cyanamid Co.'s Plastics and Resins Div. has begun operations in its new development laboratory in Wallingford, Conn.

Atlantic Div. is the new name for Aerojet-General Corp.'s **Ordnance Engineering Div.**

General Electric Co. has begun construction of a $827,000 turbine rotor balance and overspeed test facility in Schenectady, N. Y.

Chester Products, Inc., is the new name of the company formed by the merger of **Chester Products Co.,** a division of Ransohoff, Inc., and **Fabricated Steel, Inc.**

Skycrafters Mfg. Co., Inc., a subsidiary of Si Lite, Inc., has moved its manufacturing facilities to 2600 N. Pulaski Rd., Chicago 39.

Servo Corp. of America plans to construct a $1.5 million plant in Hicksville, L. I., N. Y., which will consolidate the research and development, manufacturing, and administrative activities of the company's six plants.

Glidden Co.'s Chemicals-Pigments-Metals Div. plans to construct a million-dollar inorganic research and development center in Baltimore.

Valco Inc., manufacturers of decorative and industrial fiber glass-reinforced paneling, is a new company located at 7500 Fourth St. N., St. Petersburg 3, Fla.

AiResearch Aviation Service Div., Garrett Corp. has acquired a nine-acre section of property for expansion of its facilities at **Los Angeles International Airport.**

Morningstar-Paisley has begun production of liquid vinyl chloride and natural and synthetic latex com-

News of Industry

pounds at its new Clifton, N.J., plant.

Fibers Div. is the new name for Celanese Corp. of America's **Textile Div.**

National Vulcanized Fibre Co. has announced plans for the acquisition of **Parsons Paper Co.**, Holyoke, Mass.

Air Reduction Sales Co., a division of Air Reduction Co., Inc., has completed a new plant located at 1100 Packard St., Kansas City, Kan. for the production of oxygen and nitrogen.

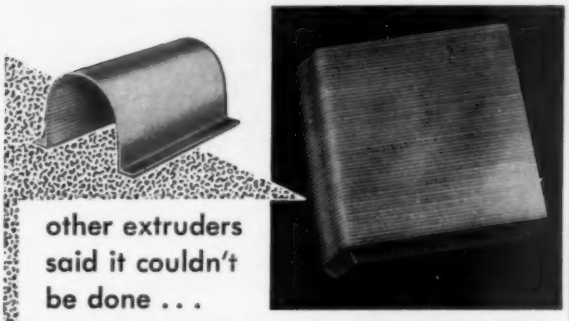
Societies

Society of Plastics Engineers, Inc., has elected the following 1959 national officers: president—Fred C. Sutro, Jr., Spencer Chemical Co.; first vice president—George W. Martin, Holyoke Plastics Corp.; second vice president—Jules W. Lindau, Southern Plastics, Inc.; secretary—Frank W. Reynolds, IBM Corp.; and treasurer—Haiman S. Nathan, Atlas Plastics, Inc.

Aluminum Assn. has elected the following officers: president—M. M. Anderson, Aluminum Co. of America; chairman of the board—S. D. Den Uyl, Bohn Aluminum & Brass Corp.; directors at large—Frank R. Nichols, Nichols Wire & Aluminum Co.; Jess E. Williams, Olin Mathieson Chemical Corp.; and C. A. Macfie, Revere Copper and Brass Inc.; and vice presidents—John W. Douglas, Republic Foil and Metal Mills, Inc.; Thomas D. Gebhart, Anaconda Aluminum Co.; and Frederick A. Merliss, United Smelting & Aluminum Co., Inc.

Powder Metallurgy Parts Mfrs. Assn. has elected the following officers: president—Kenneth M. Gleszer, Dixon Sintaloy, Inc.; first vice president—M. T. Victor, International Powder Metallurgy Co.; and treasurer—Smith Bolton, U. S. Graphite Co.

American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., has elected the following 1959 officers: president—Howard C. Pyle, Monterey Oil Co.; Society of Mining Engineers president—Jerome W. Woomer, J. W. Woomer & Assoc.; Metallurgical Society president—John Chipman, Massachusetts Institute of Technology; Society of Petroleum Engineers president—John S. Bell, Humble Oil & Refining Co.; presi-



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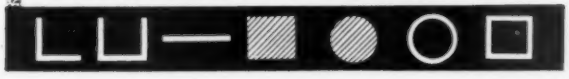

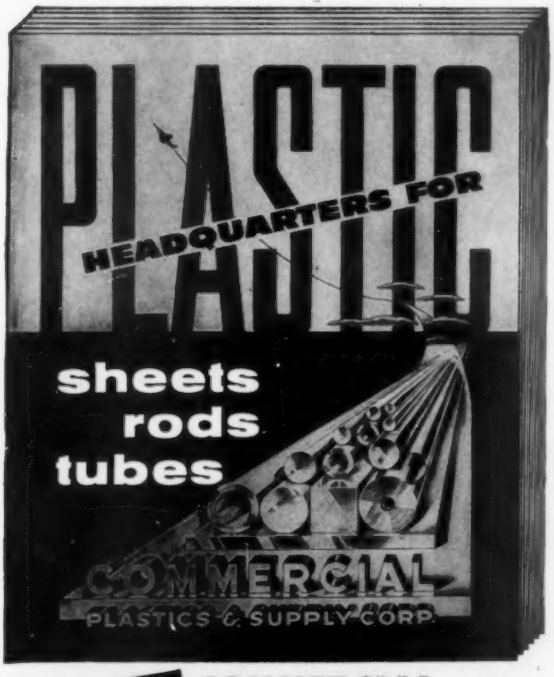

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Meetings

AMERICAN WELDING SOCIETY, 40th annual convention and welding exposition. Chicago. Apr 6-10.

AMERICAN FOUNDRYMEN'S SOCIETY, engineered castings show and 63rd annual castings congress. Chicago. Apr 13-17.

METAL POWDER INDUSTRIES FEDERATION, annual meeting. Detroit. Apr 20-22.

LEAD INDUSTRIES ASSN., 31st annual meeting. Chicago. Apr 22-23.

INSTITUTE OF ENVIRONMENTAL ENGINEERS, 3rd annual technical meeting and equipment show. Chicago. Apr 22-24.

METAL TREATING INSTITUTE, spring meeting. Hollywood, Calif. Apr 22-26.

NATIONAL SCREW MACHINE PRODUCTS ASSN., 26th annual meeting. New York City. Apr 26-30.

ELECTROCHEMICAL SOCIETY, spring meeting. Philadelphia. May 3-7.

SOCIETY OF AIRCRAFT MATERIALS AND PROCESS ENGINEERS, Eastern Div., spring meeting. New York City. May 15.

4th annual Design Engineering Conference, American Society of Mechanical Engineers. Convention Hall, Philadelphia. May 25-28.

4th annual Design Engineering Show. Convention Hall, Philadelphia. May 25-28.

AMERICAN SOCIETY FOR TESTING MATERIALS, 62nd annual meeting. Atlantic City. June 21-26.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer general meeting. Seattle, Wash. June 22-26.

METALLURGY DIV., DENVER RESEARCH INSTITUTE, 8th annual conference on applications of x-ray analysis. Estes Park, Colo. Aug 12-14.

METALLURGICAL SOCIETY, American Institute of Mining, Metallurgical, and Petroleum Engineers, conference on properties of semiconductors. Boston. Aug 31-Sept 2.

TECHNICAL LITERATURE

Books

Aluminum Foil: 1st Edition. *Kaiser Aluminum & Chemical Sales, Inc., Chicago. 1958. Cloth, 8 1/2 by 11 in., 244 pp.*

This book, said to be the most complete volume on aluminum foil ever published, contains 10 chapters illustrated with more than 350 photographs and drawings. The first four chapters give information on properties, uses, design, production and availability of aluminum foil. The last six give information on laminating, extruding, printing, coating, forming and fastening of foil. The book contains an index and a glossary.

The book is available without cost if requested on company letterhead; otherwise a charge of $12.50 is made for each personal copy.

Proceedings Fourteenth Annual Meeting, Metal Powder Association. *Metal Powder Industries Federation, New York. 1958. Cloth, 6 by 9 in., 125 pp. Price $4*

The 16 papers discuss powder metallurgy applications in the missile and rocket fields; slip casting metal powders; chromizing of iron powder parts; production of nuts and washers from brass powders; metal powders for barrel finishing; powder metallurgy in Russia and Japan; endothermic and exothermic atmospheres for sintering; and hot forming techniques for consolidating metal powders.

High Temperature Effects in Aircraft Structures. *Edited by Nicholas J. Hoff. Pergamon Press, New York. 1958. Cloth, 6¼ by 10 in., 360 pp. Price $12*

This British book, published for the North Atlantic Treaty Organization, contains new and unpublished data on the effects of aerodynamic heating on metallic and nonmetallic aircraft materials.

The book's 16 chapters, written by American and European scientists, discuss: creep and relaxation in metals; fatigue of structural materials at high temperatures; creep and stress relaxation of plastics; nonmetallic and glass-like structural materials for high temperatures; buckling caused by thermal stresses; external sources of heat; stress distribution in the presence of creep; and heat transmission in aircraft structures.

Processing of Thermoplastic Materials. *Edited by Ernest C. Bernhardt. Reinhold Publishing Corp., New York. 1959. Plastics Engineering Series. Cloth, 6 by 9 in., 700 pp. Price $18*

Well illustrated with tables and graphs, this book gives information on the processing properties of such thermoplastic materials as acrylic, cellulosic, nylon, polyethylene, polystyrene and vinyl resins. The book also gives information on extruding, injection molding, calendering, sheet forming, sealing and welding.

ASTM Standards, 1958. *American Society for Testing Materials, Philadelphia. 1958. Cloth, 6 by 9 in.*

Part 3—Methods of Testing Metals (Except Chemical Analysis). *930 pp. Price $10.* Included are standards for tension, compression, bend, hardness, impact and creep tests; metallography; magnetic

TECHNICAL LITERATURE

particle tests; corrosion and surface coating tests; electrical and magnetic property tests; ultrasonic tests; thermal analysis; heat treatment; and nondestructive tests.

Part 4—Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils. *1458 pp. Price $12*

Mechanical Properties of Non-Metallic Brittle Materials. *Edited by W. H. Walton. Interscience Publishers, Inc., New York. Cloth, 6 by 10 in., 500 pp. Price $12.75*

Although this book is concerned primarily with coal and concrete, some chapters are devoted to the mechanical properties of glass, ceramics, carbon and graphite. The book contains a subject and name index, and is well illustrated with graphs, tables and photographs.

Machinery's Mathematical Tables. *Edited by Holbrook L. Horton. Industrial Press, New York. 1958. Cloth, 4½ by 7¼ in., 258 pp. Price $3.75*

This book contains mathematical tables giving circumferences and areas of circles; volume of spheres; natural trigonometric functions; logarithms of trigonometrical functions; weights and measures; and decimal equivalents.

The Contemporary Curtain Wall: Its Design, Fabrication and Erection. *William Dudley Hunt Jr. F. W. Dodge Corp., New York. 1958. Cloth, 7 by 10 in., 482 pp. Price $12.75*

This volume, although an architectural book, may be of interest to the design engineer because it contains a great deal of information on the properties, uses, design and fabrication of prefabricated metallic and nonmetallic materials.

Materials discussed in the book include: stainless steel, aluminum, copper and copper alloys, galvanized metals, carbon steel, magnesium, composite metals, porcelain enamel, glass, plastics and wood.

Reports

Hydraulic seals EVALUATION OF HIGH TEMPERATURE HYDRAULIC SEALS TO TEMPERATURE OF 550 F: PART 1—MECHANICAL EVALUATION. *Charles W. Galloway, Douglas Aircraft Co., Inc. for Wright Air Development Center. Feb '58. 143 pp. Available from Armed Services Technical Information Agency, Arlington Hall Station, Arlington 12, Va. (ASTIA No. AD 142079)*

The program discussed in this report was conducted for the purpose of evaluating and developing hydraulic seals and packings for use in high temperature hydraulic systems using either OS-45 or MLO-8200 fluids at operating temperatures of 400 F and 550 F respectively. Of numerous materials evaluated, Viton rubber was the only material that operated well at 550 F.

Fatigue of steel RESEARCH ON FERROUS MATERIALS FATIGUE. *H. N. Cummings, F. B. Stulen and W. C. Schulte, Curtiss-Wright Corp. Aug '58. 114 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.50 (PB151243)*

Included are three studies on the effect of fatigue stressing steel R. R. Moore rotating beam specimens.

Heat resistant alloys RESEARCH ON HEAT RESISTANT ALLOYS STRENGTHENED AT ELEVATED TEMPERATURES BY INCORPORATION OF FINE PARTICULATE SUBSTANCES. *Sintercast Corp. of America. Dec '58. 28 pp. Available*

TECHNICAL LITERATURE

from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1 (PB 131846)

Information on a high density 80-20 nickel-chromium alloy matrix containing uniform dispersions of hard-phase addition agents. At 1500 F the stress-rupture properties of this matrix material increased considerably. The most favorable results were obtained with additions of titanium carbide and alumina.

Magnet materials RESEARCH ON FINE-PARTICLE PERMANENT MAGNET MATERIALS. *A. E. Berkowitz and W. J. Schuele, Franklin Institute. Apr '58. 50 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.50 (PB151262)*

Co-precipitating cobalt-iron, nickel-iron and copper-iron oxalates is an excellent method for producing fine particles with a wide range of magnetic properties. Particles produced included metals, alloys, ferrites and other oxides.

Molybdenum TECHNOLOGY OF MOLYBDENUM AND ITS ALLOYS. *A symposium sponsored by the Office of Naval Research. Sept '56. 16 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 75¢ (PB 131793)*

Molybdenum as a structural material; its preparation and metallurgy; developments in European technology; and use of molybdenum alloys in gas turbines.

Plastic sandwich panels BUILDING WITH PLASTIC STRUCTURAL SANDWICH PANELS. *Edited by Bernard P. Spring, Massachusetts Institute of Technology, School of Architecture & Planning. 1958. 121 pp. Available from Monsanto Chemical Co., Plastics Div., Springfield 2, Mass. Price $3.*

Properties, design and fabrication of plastics now used in sandwich panel construction.

Heat resistant electronic parts ELECTRONIC COMPONENT PARTS RESEARCH FOR 500 C OPERATION: PART 2. *M. E. Goldberg, H. G. Hamre and R. D. Noble, Armour Research Foundation, July '58. 91 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 151320)*

Deposition of "slurry ceramics," a combination of a ceramic and an inorganic binder, onto metal substrates proved the best of several techniques for the fabrication of capacitors and insulated wire operating at 950 F.

Wrought SAP-type alloys A PROPOSED MECHANISM FOR THE STRENGTHENING OF SAP-TYPE ALLOYS. *G. S. Ansell, Naval Research Laboratory. Oct '58. 4 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 151047)*

This report indicates that an adjustment in the manufacturing techniques for sintered metal powder alloys (SAP-type alloys) may lead to materials with greater tensile strength and ductility.

Metal powder standards STANDARDS FOR THE METAL POWDER PRODUCERS ASSOCIATION. *1958. Metal Powder Industries Federation, 130 E. 42nd St., New York 36. Price $6 per set*

Included in the standards are methods for sampling metal powders, and methods for determining hydrogen loss, flow rate and apparent density of metal powders. A set of standard definitions of powder metallurgy terms is included along with a data sheet listing commercially available grades and types of metal powders and their manufacturers.

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THE LAST WORD

Read and Wake Up

by ***H. R. Clauser***
Editor

How many books outside of your own technical specialty have you read recently? The statistics show that only about 40% of us have read one or more books during the past year. As a nation we read fewer books than any other Western country. For example, only 20% of all adults in the United States are reading a book at any one time as compared to 60% in England.

I doubt that the amount of reading done by engineers is any more than that indicated by the figures just cited. So the reading habits of engineers, like most Americans, could stand improvement.

Reading makes connections

There are some important reasons why engineers can profit by making it a regular practice to read good books in fields other than their own. For one thing, extracurricular reading is particularly important to the creative aspects of engineering. We engineers are reared to a large extent on straight factual knowledge. And in our day-to-day work we deal almost exclusively with objective facts.

This is as it should be. But at the same time we should be aware of a danger that lies in complete preoccupation with empirical facts. The sheer weight of factual knowledge can stifle the creative imagination and prevent the "leaps in the dark" that often lead to revolutionary new developments.

It is widely recognized that reading is one of the most important stimulants for the creative imagination. By reading in many diverse fields, we are led to resemblances and analogies between apparently dissimilar things, and often we suddenly hit upon connections that lead to the solutions of engineering problems.

There are no knowledge monopolies

Unfortunately, many engineers and scientists hold the belief that only *they* are dealing with "truth" and that their approach is the only path to knowledge. Therefore, they believe that such things as literature and philosophy are unreal and should be cultivated only for pleasure or should be avoided as being a waste of time.

But it is doubtful that science and engineering have a monopoly on knowledge. Most leaders in science and engineering recognize other sources of knowledge. The arts and humanities still have much to tell us about man and the world. To ignore these sources is to deprive ourselves of a large portion of knowledge accumulated over the ages.

The whole man gets around

It is the whole man with whom we should be concerned. All fields, and engineering in particular, have been fragmented into hundreds of specialties. This cannot be changed—even if it could we might not want to.

But somehow we need to retain an awareness and appreciation of the other aspects of the "human condition." We need to try to achieve some sort of balance among the many different sources of knowledge and understanding. Reading that ranges far and wide into many different fields can help us approach this balance. It can give us the broad perspective we need to be a whole man.

This month, National Library Week (Apr 12-18) is being celebrated. The theme for the event is "Wake Up and Read." As you can see, the order of the words has been rearranged in the title of this editorial. The new order, I think, tells a more accurate story. Reading is an awakening experience. It is when we stop reading the printed word that we are likely to fall asleep and lose the rich contribution that books can make to our lives and work.

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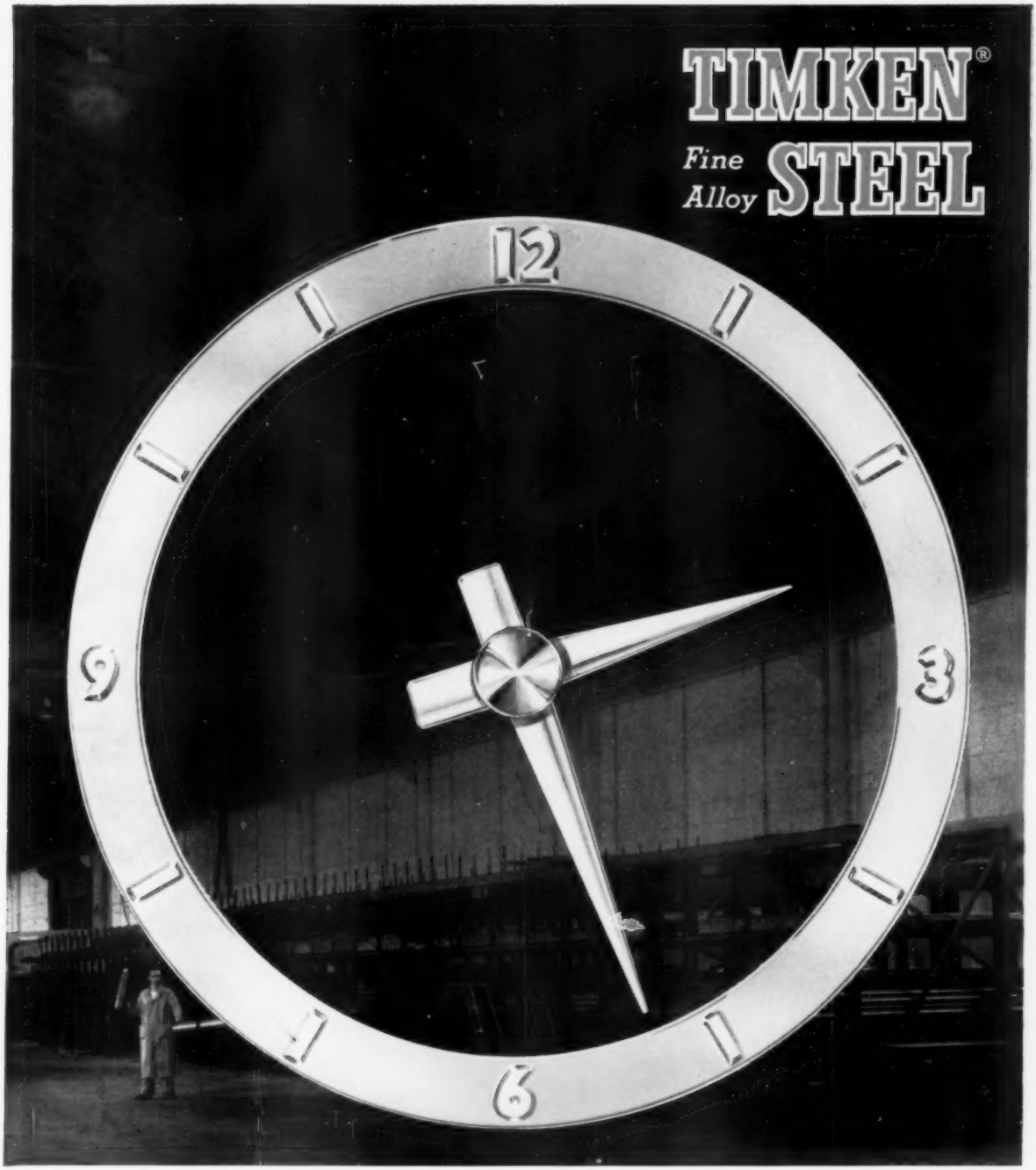

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